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ABSTRACT

This study describes the basic mathematics programs used in, and develops a set of recommendations for, the curriculum at Saddleback College. A survey of the mathematics chairpersons of 105 California community colleges and of the mathematics department faculty was conducted for use in beginning a four-part Delphi exercise. Based on the results of the Delphi exercise it was recommended that the Saddleback College program consist of an optional, tutorial laboratory course and two arithmetic/introduction to algebra courses. One of the latter courses would be directed at those students needing extensive development work in this area and the other would be designed for those needing only a review or those already in possession of a high level of computational skills. Cost analysis for the recommended system was reported. Learning environment surveys, the Delphi questionnaires and results, and material for program cost analysis are provided in appendices. (Author/YP)

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IMPROVING THE BASIC MATHEMATICS PROGRAM
AT SADDLEBACK COLLEGE

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by

Steven C. Sworder

A Major Applied Research Project presented in
partial fulfillment of the requirements
for the degree of Doctor of Education

Nova University

May, 1989

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Abstract of a Major Applied Research Project Presented
to Nova University in Partial Fulfillment of the
Requirements for the Degree
of Doctor of Education

IMPROVING THE BASIC MATHEMATICS PROGRAM AT SADDLEBACK COLLEGE

by

Steven C. Sworder

February, 1989

The purpose of this case study was to describe the basic mathematics programs used by the California community colleges and to develop a set of recommendations for the basic mathematics curriculum most appropriate for Saddleback College (CA).

A survey of the mathematics chairpersons of the 105 degree granting California community colleges was conducted to determine the learning environments available to basic mathematics students in this college system. The current catalog of each of these schools was studied to provide the data necessary to describe the organizational patterns for basic mathematics courses and programs used in the community colleges in California.

A four-part Delphi exercise was conducted using the Saddleback College mathematics department faculty as the respondent group. This group decision technique was used to

determine what course content, organization, and learning environments were most appropriate for the Saddleback College basic mathematics program.

Before beginning the Delphi process the Saddleback College mathematics faculty was informed of the results of the statewide survey. The results included the fact that each of the 105 colleges had a basic mathematics program and that in all but three cases it was part of the mathematics department. While the basic mathematics courses were present in three general categories, the most common was an arithmetic class that included addition, subtraction, multiplication, and division using whole numbers, fractions, and decimals. This course also covered percent, applications, measurement, and (often) applied geometry. While sixty-five percent of the California colleges had such a course, forty-six percent had only this course in the basic mathematics curriculum. The most frequent format of basic mathematics instruction was a structured learning situation that was instructor-paced and involved live lectures. This format was used at ninety-five colleges and was the only format available at sixty-one. The services of a mathematics learning center were used in thirty-seven colleges to support basic mathematics instruction while twenty-nine colleges used the general college learning center in this program.

Before beginning the Delphi exercise, the mathematics faculty was also informed that the population of Saddleback College basic mathematics students was, on the average, older, and had a higher percentage of new students to the college and women students than did the population of algebra students. These conclusions were revealed following hypothesis tests based on random samples of one hundred students from each population.

Based on the results of the Delphi exercise it was recommended that the Saddleback College program consist of an optional, tutorial laboratory course and two arithmetic/ introduction to algebra courses. One of these latter courses would be directed at those students needing extensive developmental work in this area and the other would be designed for those needing only a review or those already in possession of a high level of computational skills.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS ii

ABSTRACT iii

LIST OF TABLES xi

LIST OF FIGURES xii

Chapter

1. INTRODUCTION 1
   - Statement of the Problem 4
   - Background and Significance 8
   - Major Issues and Research Questions 12
   - Hypotheses 14
   - Purpose of the Study 16
   - Definition of Terms 17
   - Limitations of the Study 20
   - Assumptions of the Study 21
   - Conclusion 21
2. REVIEW OF RELATED LITERATURE 22
   - Introduction 22
   - Importance of Arithmetic Instruction at the Postsecondary Level 23
   - Importance of Careful Program Development . . . 26
     - Student Diversity 27
   - Appropriate Instructional Methods for Basic Mathematics Courses 28
     - Program Flexibility -- Variety of Methods . . 29

TABLE OF CONTENTS (Cont.)

Chapter Page

Individualized Instruction 32

Mastery Learning 34

Lecture Method -- Traditional Class Structure 35

Eclectic Approach 37

Computer-Aided Instruction 39

Other Instructional Technologies 41

Summary of Instructional Methods 44

Remedial Mathematics Instructors 45

Instructional Support Services 46

Tutors 47

Mathematics Learning Centers 48

Basic Mathematics Course Content 51

Structure of the Basic Mathematics Program . . 53

Administrative Jurisdiction Over the Remedial Mathematics Program 54

Summary of the Review of Related Literature . . 56

3. PROCEDURES AND METHODOLOGY 58

Review of Curriculum Literature 59

Basic Mathematics Learning Environments Available in the California Community Colleges 60

Population 61

Questionnaire Development 62

Survey Administration 64

Comparison of Basic Mathematics and Algebra Student Demographics 68

TABLE OF CONTENTS (Cont.)

Chapter Page

Sample 68

Recommendations for Improving the Basic Mathematics Program at Saddleback College . . 74

Program Cost Analysis 80

4. PRESENTATION OF RESULTS 83

Review of the Basic Mathematics Programs in the California Community Colleges 83

Survey of the Basic Mathematics Learning Environments Available in the California Community Colleges 94

Comparison of Basic Mathematics and Algebra Student Demographics 102

Hypothesis 1 -- Mean Age 102

Hypothesis 2 -- Mean Number of Units Completed 103

Hypothesis 3 -- Mean Grade Point Average . . 103

Hypothesis 4 -- Proportion of Students With No Units Completed 104

Hypothesis 5 -- Sex Distribution 105

Hypothesis 6 -- Proportion of White, Not Hispanic Students 105

Hypothesis 7 -- Ethnic Distribution 106

Recommendations for Improving the Basic Mathematics Program at Saddleback College . . 107

Program Objectives, Organization, and Support Services -- Delphi Rounds One and Two 107

Faculty Program Recommendations -- Delphi Rounds Three and Four 112

Evaluation of Program Recommendations 116

Program Cost Analysis 117

TABLE OF CONTENTS (Cont.)

APPENDIXES Page

F. THIRD ROUND DELPHI COVER LETTER AND QUESTIONNAIRE 175
G. FOURTH ROUND DELPHI COVER LETTER AND QUESTIONNAIRE 183
H. FOURTH ROUND DELPHI RESULTS 193
I. PROGRAM COST ANALYSIS 201
BIOGRAPHICAL SKETCH OF PARTICIPANT 206

TABLE OF CONTENTS (Cont.)

Chapter Page

5. INTERPRETATION, CONCLUSIONS, AND RECOMMENDATIONS 119

Interpretation of Results 119

Review of the Basic Mathematics Programs in the California Community Colleges . . . 119

Survey of the Basic Mathematics Learning Environments Available in the California Community Colleges 121

Comparison of Basic Mathematics and Algebra Student Demographics 123

Saddleback College Program Recommendations . 126

Program Cost Analysis 128

Conclusions 129

Recommendations for the Improvement of Educational Practice 130

Strategies for Diffusion 131

Strategies for Implementation 132

Strategies for Improvement 132

Signifcance of the Project 133

BIBLIOGRAPHY 134

APPENDIXES

A. LEARNING ENVIRONMENTS SURVEY PILOT VERSION . . . 145

B. LEARNING ENVIRONMENTS SURVEY FINAL VERSION . . . 149

C. FIRST ROUND DELPHI COVER LETTER AND QUESTIONNAIRE 153

D. SECOND ROUND DELPHI COVER LETTER AND QUESTIONNAIRE 162

E. SECOND ROUND DELPHI EXERCISE RESULTS 169

LIST OF TABLES

Table Page

1. Arithmetic Fundamentals Scheduling Format for Non-Modular Courses 87
2. Arithmetic Fundamentals Scheduling Format for Modular Courses 87
3. Arithmetic Scheduling Format Non-Modular Courses 89
4. Arithmetic Scheduling Format Modular Courses . . 90
5. Arithmetic/Introduction to Algebra Scheduling Format for Non-Modular Courses 92
6. Arithmetic/Introduction to Algebra Scheduling Format for Modular Courses 93
7. Tutoring Classes Schedule Format 94
8. Ethnic Distribution of Student Samples 106
9. Delphi Round Two Rank Order Responses 108

LIST OF FIGURES

Figure Page

1. Distribution of the Basic Mathematics Course Among the California Community Colleges . . . 86

2. Distribution of Lecture Availability Among the Colleges 95

3. Distribution of the Textbooks Among the California Community Colleges 96

4. Distribution of Instructor Handouts Over the Types of Books Used for Basic Mathematics Courses 97

5. Distribution of Media Used for Basic Mathematics Among the Colleges 98

6. Distribution of Instructional Location Among the Colleges 99

7. Distribution of Tutoring Personnel Among the Colleges 100

8. Distribution of Tutoring Location Among the Colleges 101

9. Distribution of the Basic Mathematics Courses Supported by the Saddleback College Mathematics Faculty 114

10. Basic Mathematics Program Flowchart 116

Chapter 1

INTRODUCTION

The recent reassessment of the California community colleges by the Commission for the Review of the Master Plan for Higher Education (1986:1), hereafter referred to as the Commission, affirmed the commitment to open access community colleges made in the early 1900s by the State of California. This commitment was made an integral part of the original California master plan for higher education that was enacted into California statute as the Donahoe Higher Education Act of 1960. With this reaffirmation, however, came the qualification that the access be meaningful. The community colleges had to be a quality component of postsecondary education in the state and one that helped ensure the success of all students who enrolled (Commission for the Review of the Master Plan for Higher Education, 1986:2).

The maintenance of an open access segment of higher education in California has not come without problems. The Board of Governors of the California Community Colleges, hereafter referred to as the Board, found that during the extended period of curriculum growth and increasing diversity in the educational objectives, background, and abilities of entering students beginning in the 1960s, there was

> a lack of clear and commonly held criteria for distinguishing associate degree applicable offerings from those others that were found to be necessary to

14

> respond to the needs of students who entered the "open door" (Board of Governors of the California Community Colleges, 1985:3).

Because of the relative autonomy of the individual community colleges in the California system, various practices and standards were adopted to deal with this situation. These often included the lowering of standards in existing collegiate courses or creation of new courses to accommodate underprepared students (Board of Governors of the California Community Colleges, 1985:3). The Board (1985:3) further observed that the various practices and standards used by the colleges to determine which courses applied to the associate degree had permitted such variability in rigor and structure of the degree that it had lost much of its credibility.

In an effort to strengthen the associate degree and insure the quality of the community college system called for by the Commission, the Board adopted regulations that established a distinctive set of standards for degree applicable courses (Board of Governors of the California Community Colleges, 1986:1). Adopted in May, 1986 and designed for implementation on July 1, 1988, these regulations were submitted for approval to the Office of Administrative Law, as required by state statute. Because of certain procedural errors, these regulations were not approved for July, 1988 implementation (Dixon, 1987:1). Dixon (1987:1) estimated that these new regulations would be effective July 1, 1989. Mean while, the Board asked the board of trustees of each California community college to voluntarily comply with the provisions of the new regulations. The Saddleback Community College District Board of Trustees and the Saddleback College Academic Senate agreed to this request. Associate degree graduation requirements consistent with the pending regulations were created and implemented at Saddleback College for the 1988-1989 academic year.

In addition to the focus on program and degree quality by the Board, the California Legislature (1988:33) also addressed the issue of quality in its legislated mandate that the primary mission of the community colleges be the establishment of instructional programs that provide for "rigorous, high quality degree and certificate curricula in lower division arts and sciences and in vocational and occupational fields." To support the primary mission for the community colleges, the California Legislature (1988:33) recognized the provision of remedial instruction and support services that help students succeed at the postsecondary level as "essential and important functions" of the colleges.

The recent reform efforts by the California Legislature and the Board served to separate the college associate degree and remedial curricula. This separation had the goal of ensuring the high quality of both and the ultimate success of students. These changes, also, gave the individual colleges the opportunity to reevaluate course offerings and provided immense political and professional support for those within the college who sought curriculum improvement. It was the Commission (1986:2) that issued "the challenge of change" but it will be the community colleges themselves, leaning on their great strengths of diversity, accessibility, and sensitivity to local needs that will meet this challenge and supply the support necessary for Californians to successfully meet the challenges of the twenty-first century.

Statement of the Problem

The acceptance, at Saddleback College, of the regulations strengthening the associate degree had a direct impact on the mathematics curriculum of the college. These regulations required that degree applicable courses be at or above the level of beginning algebra. Consequently, completion of the arithmetic course, basic mathematics, could no longer be used by a student as a means of demonstrating mathematics proficiency. Such a demonstration was required for graduation with an associate degree. Basic mathematics lost the college level status with which it had been associated since the founding of the college in 1967.

Although often used as a developmental course by those students seeking preparation for algebra and other quantitatively based courses needed for transfer to a four-year college or university, the college level status held by basic mathematics protected it from any special attention separate from the rest of the curriculum. It was always viewed as just another three unit lecture class with respect to scheduling, staffing, and dedication of resources. During the 1988 spring term, this course accounted for fifteen percent of the 2827 students enrollment in mathematics courses. It was offered only in a lecture format and met three hours each week. Three of the eight sections were offered as large lecture classes and enrolled an average of sixty-nine students. These sections enrolled forty-nine percent of the students taking basic mathematics. Seven sections were staffed with part-time faculty and the remaining section was assigned to a full-time instructor as an over-load assignment.

Of course, many members of the mathematics faculty recognized that this course, more than any other in the department curriculum, attracted students with a wide range of mathematics skills and aspirations. On the average, forty percent of the students enrolled in basic mathematics completed the course with a grade of C or better. Historically, this low success rate was not viewed with particular alarm. The course was considered an end in itself. It was a graduation requirement. As with other college courses, it remained the student's responsibility to successfully meet the degree requirements set by the college. However, the mathematics faculty was frustrated by the lack of success of so many students in this course.

The full-time faculty generally dealt with their frustration by deciding not to teach the course. Over the five year period from the 1984 spring term through the 1988 fall term, six different full-time instructors (from the fourteen possible) taught sixteen class sections of the total ninety-one class sections of basic mathematics offered. The maximum number of sections taught by a single full-time mathematics instructor over this five year period was four and the average number of sections taught by the entire group of six instructors was 2.5 sections.

The change in status of the basic mathematics course from college level to remedial in the 1988 fall term was not accompanied by a modification or review of the course curriculum. The only deviation from standard practice was the removal of large lecture sections. This was done because the Academic Senate (1987:2) opposed the use of large lecture classes for remedial courses. All basic mathematics class sections (twelve sections) had a maximum enrollment of forty-five students, as set by contract between the Saddleback Community College District and Saddleback Community College District Faculty Association (1987:27).

It was the consensus of opinion of the mathematics department faculty that the existent arithmetic course was not appropriate for a curriculum component that primarily served a developmental function. Originally designed as a college level course, it no longer met the needs of students nor the objectives set for it by the college. Continuation of a low student success rate was unacceptable to both students who sought admission to college level courses with a reasonable expectation of success and to the mathematics faculty who sought well prepared students for these entry level college courses. Further, this low success rate was contradictory to the commitment of the college to maintain appropriate educational programs and developmental courses (Saddleback College, 1988:4).

The typical preparation for a community college instructor was a master's degree obtained in a traditional academic department (Cohen and Brawer, 1982:76). This general description of faculty preparation accurately reflected the academic background of the Saddleback College mathematics faculty. Twelve of the fourteen full-time mathematics instructors held master's degrees in mathematics. They were skilled mathematicians and quality teachers. Master's degree programs in mathematics, however, focused on the development of mathematical subject area competencies. These programs rarely included a pedagogical component. This was noted by Friedlander (1979:5) who recommended that "instructors should be provided with special training in teaching remedial mathematics to community college students." Both McCabe (1981:10) and Roueche (1984:22) noted this lack of training in teaching strategies applicable to nontraditional students and called for steps to be taken to improve faculty competency in this area. This lack of specific training, typical to community college instructors, caused the mathematics faculty to be uncertain about the modifications most appropriate for the college basic mathematics program.

Rumors from chance professional conference conversations and occasional journal articles concerning successes and failures with mathematics remediation were casually shared between individual faculty members. The lack of an organized analysis of the state-of-the-art of mathematics remediation in the context of Saddleback College student characteristics and faculty preferences prevented the mathematics faculty from coming to a full understanding of the situation and carrying forward a solution to the college Academic Senate and Curriculum Committee.

Background and Significance

Deciding how to deal with that portion of the student population underprepared for regular college work has been an issue for those involved with American higher education from its inception (Cohen and Brawer, 1982:229). The response has ranged from simply denying these students college entry by raising the admissions requirements to establishing preparatory departments that channeled students into collegiate programs. For example, Rudolph (1962:281) reported that every state in the nation, except five northeastern states where the academy movement was strong, had at least one college that had offered preparatory work as long ago as 1872.

The origin of the current focus on remediation in higher education was linked to the massive expansion of postsecondary education in the 1960s. Along with comparable development in other states, the explosive growth of state higher education systems in California attracted new students who would otherwise never have been able to attend college (McGrath and Spear, 1987:12). The community colleges saw an opportunity in this growth to align themselves with higher education, rather that with the public schools, by making a claim to the postsecondary remediation function (McGrath and Spear, 1987:12).

This role for the community college was, of course, not a new idea. The need to provide remediation for students seeking entrance to four-year colleges and universities was among the motivation that led to the growth of community colleges after 1920 (California Postsecondary Education Commission, 1983:7). In some ways this effort was successful because it left the community colleges generally accepted as the primary provider of postsecondary remediation in California (Commission for the Review of the Master Plan for Higher Education, 1986:10; Farland, 1985:11; Smith, 1985:11).

The fact that community colleges must share this function with the other segments of higher education resulted from the decline in the college age population. The population decline created a competition for students that resulted in relaxed admissions requirements to the four-year institutions (Cohen and Brawer, 1982:230). This served to focus the community college efforts at the most basic level. Akst (1985:143) reported that while over the period 1966 to 1980 national two-year college mathematics enrollment tripled, the registration in arithmetic was eight times its former size. Over this period, it was the group of very weakest students that grew most rapidly in community colleges.

The effects of the growth of the population of developmental students have been dramatic. Cohen (1985:54) observed that most two-year colleges had been forced to modify all of their programs to accommodate the marginally literate students coming from the high schools. The colleges themselves could not escape at least partial responsibility for their lowering standards. Roueche, Baker, and Roueche (1987:33) found that by allowing quasi-literate students into college-level courses, community colleges often had forced faculty to compromise standards of instruction. McGrath and Spear (1987:19) claimed that

> teachers, committed to one particular instructional style, the classroom lecture, and to the limited instructional goal of information transfer, respond to underprepared and indifferent students by simply watering down requirements.

From these observations, it was clear that a college faculty could not be casual about the developmental students it serviced and the remedial programs it offered. In fact, Cohen and Brawer (1982:231) felt that the "thorniest single problem for community colleges" was the guidance and instruction of the developmental student. The California Postsecondary Education Commission (1983:27) reported that

> Remediation has become a pervasive issue, affecting the very heart of the educational endeavor. Administrators worry about it; faculty are daily faced

> with it; students suffer from it; newspapers inveigh against it; and the public pays for it.

The designation of a remedial mathematics component for the Saddleback College curriculum in the 1988 fall term came, coincidentally, at a critical time in the physical development of the college itself. Planning began in this same semester for the construction of an addition to the existing science/mathematics building. This 17,000 square foot structure, scheduled for occupancy in 1992, was designated to house the mathematics and computer science programs (Bartlett, 1988:2). Critical to the design of this facility was a complete description of the curriculum, learning environments, and instructional techniques it would be required to support. The present Major Applied Research Project became an important tool in the preliminary design phase of this building, because it identified those components necessary for a program not yet in existence but planned to be operational before the building construction was completed.

The significance of this work to the improvement of educational practice at Saddleback College was recognized by several distinct components of the college community. The college Academic Senate awarded a grant to support much of the document reproduction and acquisition needed for the literature review. The Saddleback Community College District faculty and administration approved, and the Board of Trustees granted a sabbatical leave to provide the time necessary for a careful collection and analysis of the data.

Reports on the progress of the study were made a regular part of the meetings of the mathematics department and of the committee focused on the preliminary design of the science/mathematics building addition. The mathematics faculty demonstrated their support by eagerly participating in the processes required to determine their preferences for arithmetic program components. Faculty members, generally, returned questionnaires several days in advance of the given deadlines.

Developmental programs have continued to hold a significant place in higher education. In fact, Roueche and Baker (1987:72) concluded that developmental courses were "the heart of an open-door college." These programs and courses have changed in order to adequately serve the needs of the students who have enrolled in them. Because the mathematics remediation needs of Saddleback College students have changed, the college mathematics curriculum must be modified. The present MARP was undertaken to provide direction for this change.

Major Issues and Research Questions

The critical issues concerning the basic mathematics course at Saddleback College revolved around the appropriateness of the existing curriculum and available instructional delivery systems. The area of developmental studies at the postsecondary level had received a great deal of attention at both the state and national levels. To gain an appreciation for what other colleges had learned from their experience with the instruction of basic mathematics, the following two questions were addressed:

1. What organizational patterns for basic mathematics courses and programs were used in the community colleges in California?

2. What learning environments were available to students in the basic mathematics programs of the California community colleges?

The answers to these questions and the remaining activities of this study were used to support the following research question:

3. What course content, organization, and learning environments were most appropriate for the Saddleback College basic mathematics program?

Because implementation of these recommendations was expected to depend upon the amount of financial resources required above the existent level of funding for basic mathematics instruction, an answer to the following research question was sought:

4. What cost would be associated with the implementation and maintenance of this recommended program and how did the cost compare with the current level of funding for the basic mathematics program area?

Hypotheses

Members of the full-time mathematics faculty at Saddleback College rarely taught sections of the basic mathematics course. In the last five years only six of the fourteen full-time mathematics instructors had taught at least one section of this course. This was very different from their exposure to students in the beginning and intermediate algebra classes. In that same five year period, 1984 spring term through the 1988 fall term, every full-time mathematics instructor had taught at least two class sections of these courses. The average number of sections taught by the fourteen full-time instructors was ten over that five year period.

Although very much aware of the general characteristics of students enrolled in algebra courses, the mathematics faculty, because of this limited contact, may not have known those student characteristics specific to the basic mathematics course. To remove this uncertainty concerning the demographics of basic mathematics students, seven research hypotheses were tested. In each case, the null hypothesis was simply that no significant difference existed between the population of basic mathematics students and the population of students enrolled in the beginning or intermediate algebra courses. The associated alternate hypothesis was, in each case, that a significant difference did exist between these populations. The specific null hypotheses, $(H_o)_i$, were:

$(H_o)_1$: There was no significant difference in the mean age between those students enrolled in Basic Mathematics and those students enrolled in Beginning or Intermediate Algebra.

$(H_o)_2$: There was no significant difference in the mean number of units completed at Saddleback College between those students enrolled in Basic Mathematics with more that zero units completed and those students enrolled in Beginning or Intermediate Algebra with more than zero units completed.

$(H_o)_3$: There was no significant difference in the mean grade point average at Saddleback College between those students enrolled in Basic Mathematics and those students enrolled in Beginning or Intermediate Algebra.

$(H_o)_4$: There was no significant difference between the proportion of students with no units completed at Saddleback College and enrolled in Basic Mathematics with such students enrolled in Beginning or Intermediate Algebra.

$(H_o)_5$: There was no significant difference between the sex distribution of students enrolled in Basic Mathematics and the sex distribution of students enrolled in Beginning or Intermediate Algebra.

$(H_o)_6$: There was no significant difference between the proportion of white, not Hispanic students enrolled in Basic Mathematics with the proportion of such students enrolled in Beginning or Intermediate Algebra.

$(H_o)_7$: There was no significant difference between the ethnic distribution of students enrolled in Basic Mathematics and the ethnic distribution of students enrolled in Beginning or Intermediate Algebra.

Purpose of the Study

The purpose of this study was: (1) to describe the basic mathematics programs used by the California community colleges, (2) to identify demographic differences between those Saddleback College students enrolled in the basic mathematics program and those enrolled in the algebra courses, (3) to develop a set of recommendations for the basic mathematics curriculum most appropriate for Saddleback College, and (4) to investigate the practicality of these recommendations through a comparison of the cost of a program founded on these recommendations with the current level of funding available for basic mathematics instruction at Saddleback College.

Definition of Terms

The following terms were used in this study:

Audio-Tutorial Instruction (A-T)--This term referred to a learning system that used an audio tape as the programming device (Cross, 1976:83).

Audio-Video-Tutorial (AVT)--This term refers to a learning system using a coordinated audio tape and slide projection sequence as the programming device.

Basic Mathematics -- Those mathematics courses generally offered to students prior to their enrollment in beginning algebra were referred to as basic mathematics.

Computer-Aided Instruction (CAI)--This term referred to the use of computers and associated software to interact tutorially with a student as he moved through a learning exercise (Cross, 1976:61).

Delphi Exercise. -- As described in Linstone and Turoff (1975:5), the Delphi exercise is a group decision technique that does not require the individuals in the group to meet together. Through a sequence of questionnaires and reports to the participants detailing previous group responses critical issues are identified or consensuses approached.

Developmental Courses and Developmental Programs -- These terms were used synonymously with remedial courses and remedial programs as defined below.

Mastery Learning--This term referred to the pedagogical concept that learning must be thorough. One unit of material must be learned and a high level of competency demonstrated before the student was allowed to move to the next unit (Cross, 1976:77).

Programmed Instruction--This instructional technique consisted of a series of activities or "frames" that were carefully designed to produce the desired student response. Test questions were included in the program to provide immediate reinforcement and feedback to the student (Cross, 1976:56).

Remedial Courses and Remedial Programs -- These phrases were used to describe courses and support services needed by students to overcome deficiencies in reading, writing, and mathematics to a level at which these students had a reasonable chance of succeeding in regular college courses, including vocational, technical, and professional courses (California Postsecondary Education Commission, 1983:3).

The equivalency of the adjectives remedial and developmental was not uniformly accepted by authors in this area of study. Cross (1976:31) and Roueche (1968:viii), among others, suggested that remedial be applied only to programs whose goal was the removal of specific academic deficiencies in preparing the student for future college work. Developmental programs were seen, however, as a more holistic attempt to develop the attitudes, talents, and strengths of the student independent of the specific requirements of another academic program.

The California Education Code contained the term remedial exclusively (California Legislature, 1988). The California Legislature would likely view developmental programs as a variation or style of remedial programs and would not exclusively use the term remedial in legislation as a means of requiring that the general development of an underprepared student not be attempted. On the other hand, Saddleback College curriculum literature did not use the term remedial (Saddleback College, 1988). It was likely, however, that there was an expectation by the students, faculty, and administration that graduates of developmental courses would be prepared for entry into college level programs. It was felt appropriate for this study to follow the model chosen by Jorgensen (1981:5) and use these terms interchangeably.

That this position had become the standard nationally for two-year college mathematics programs could be seen from the program of the fourteenth annual convention of the American Mathematical Association of Two-Year Colleges held in Calgary, Alberta, Canada October 26-30, 1988. Presentations were categorized according to their emphasis. Only the term "developmental" was used for such a category. Developmental presentations included four sessions that used the word "developmental" in their title and two sessions with the term "remedial" in their title. Other presentations related to arithmetic, pre-algebra, and beginning algebra with neither term used as part of the title were also included under the developmental category.

Video-Tutorial (V-T)--This term referred to a learning system that used a video tape as the programming device.

Limitations of the Study

The description of learning environments used by community colleges for basic mathematics programs was limited to those colleges in California and for the 1988-1989 academic year.

The actual program recommendations were limited in application to Saddleback College for the 1989-1990 academic year.

Program content descriptions were limited to what was in the published college catalog. Consequently, they did not include variations between individual instructors within the framework of this general description.

The courses considered were limited to arithmetic courses taught through the mathematics departments or recognized by the mathematics departments as preparatory for beginning algebra. Excluded from consideration were such courses open only to learning disabled students.

Assumptions of the Study

It was assumed that the student demographics did not change radically from one semester to the next.

It was assumed that each questionnaire was completed by a person knowledgeable about the basic mathematics program. It was also assumed that the responses were truthful and complete.

It was further assumed that the Saddleback College mathematics faculty member who chose not to participate in the Delphi exercise did so for reasons unrelated to the project, or because of a lack of interest in this particular curriculum component.

Conclusion

The problem was clear, but the solution was not. It was felt that any meaningful solution had to have roots that rested securely in what others had learned about basic mathematics programs at the two-year college level. These roots were identified and nurtured through a thorough review of the mathematics education, developmental education, and general education literature. This review was presented in Chapter 2.

Chapter 2

REVIEW OF RELATED LITERATURE

Introduction

The review of the related literature provided the foundation for this Major Applied Research Project. Before the study methodology was executed, the questionnaires written, or program models proposed, an understanding of the issues, trends, and controversies in the area of postsecondary basic mathematics instruction was necessary. The professional, developmental, and mathematics education literature was searched for references related to this subject. This literature was studied and the most relevant points included here. To give structure to such a wide range of information, this chapter was organized around several key issues. These issues were listed in the following paragraphs.

To set the proper tone for the literature review, the importance of the arithmetic course at the postsecondary level was outlined. The importance of a careful program design in this area was also discussed. It was emphasized that the principal reason for the need for such care was the existence of a great diversity of students in these programs.

Of major importance to this study were the instructional methods appropriate for use in basic mathematics courses. A separate section was devoted to these techniques. Key points of focus for this discussion were: program flexibility, individualized instruction, mastery learning, lecture method, eclectic approach, computer-aided instruction, and other instructional technologies.

The importance of the instructor in remedial mathematics courses and the supplemental instructional support services often available to students in these courses were discussed frequently in the literature. Tutoring was an important element in the success of many basic mathematics students. Mathematics learning centers and the services associated with these centers contributed significantly to the success of postsecondary developmental programs.

Several organizational issues were discussed in the literature and used to conclude this literature review. These included the basic mathematics course content and the structure of the basic mathematics program. Authors expressed opposing opinions concerning the administrative jurisdiction over the remedial mathematic program. Views on both sides were compelling.

Importance of Arithmetic Instruction at the Postsecondary Level

The college basic mathematics program was central to the development of student mathematics skills. It was the computational skills and quantitative concepts developed in this program upon which the traditional college level mathematics courses such as algebra, statistics, and mathematics for liberal arts students were based. Competency in arithmetic was a prerequisite for the remainder of the mathematics curriculum (San Francisco Community College District, 1987:196).

An understanding of arithmetic was fundamental to student advancement in quantitatively based college level courses outside the mathematics department. Many college students were found to be deficient in pre-algebra skills. Roueche, Baker, and Roueche (1987:22) observed that, by the late 1960s, courses in arithmetic were not only necessary but in fact essential at most community colleges. In her 1965 survey of arithmetic programs in the California community colleges, Kipps (1966:65) observed that every college, except two that were newly opened, offered courses in arithmetic. In a 1974 survey of selected two- and four-year colleges in twenty-one states, Baldwin (1975:12) found that arithmetic was included in the curriculum of eighty-four percent of the 104 responding institutions. From a 1977 survey of developmental courses in a national sample of 175 public and private two-year colleges it was determined that one out of every three mathematics courses at the community college was taught at a pre-algebra level (Cohen and Brawer, 1982:232).

In an analysis of the results of placement tests given to new students at South Texas Junior College, Wood (1980:61) found that, while math skills ranged from an inability to do arithmetic to a readiness for calculus, the students clustered densely about the point indicating a need for arithmetic instruction. Akst and Ryzewic (1985:16), in a national study, found that ninety-six percent of public two-year colleges included arithmetic studies as part of their mathematics course list. Based of a study completed through the Chancellor's Office for the California Community Colleges, Jardine (1986:14) estimated that 3.7 percent of entering freshman were enrolled in grade six or lower skill development courses. Piepmeier (1987:63) added that a large number of adults who entered community colleges could be classified as illiterates because of their low level or nonexistent skills in reading, writing, and figuring tasks.

It was apparent, from this discussion, that any comprehensive open door community college must address the issue of what to do with students deficient in arithmetic skills. To emphasize this fact, Roueche and Baker (1987:72) saw developmental courses as the "heart" of such institutions. In general, community college mathematics faculty acknowledged that arithmetic instruction was an important part of the mission of their institutions (Coffey, 1983:7). These professional educators joined with American society as a whole in the belief that it was unacceptable to deny a person access to the college experience because of inadequate reading, writing, and computation skills (Cohen, 1987:5), (California Legislature, 1988:14). Because community college leaders in California had pressed the role of the community college as the primary provider of remediation at the postsecondary level, they were not free as were the University of California or the California State University to suggest that the remediation be done somewhere else. In California, somewhere else was situated at the local community college (California Postsecondary Education Commission, 1983:61).

Importance of Careful Program Development

While little controversy concerning the need for basic mathematics instruction at the postsecondary level was revealed through the literature review, a consensus concerning the specification of the most appropriate program appeared more difficult to reach. Patterson and Sallee (1986:724) observed that large numbers of remedial mathematics courses had been rapidly introduced at the public colleges and universities in California. However, they noted that many of these courses had demonstrated an inability to do the task for which they were designed, because they were developed without adequate planning. The need for careful planning was stressed by Colby and Opp (1987:3) who stated that developmental studies were central to the community college curriculum. Cohen and Brawer (1982:231) believed that the teaching of students unprepared for traditional college-level studies was the "thorniest" single problem for community colleges to solve.

Particular care was necessary in the design of basic mathematics courses because, as Rotman (1986:9) suggested, they were the "most developmentally based math courses" offered in the curriculum. This situation simply compounded the already difficult task of mathematics curriculum planning that Hecht and Akst (1980:209) believed stemmed from the fact that unlike reading and writing, mathematics was very much a school subject. In other words, very little learning or reinforcement of mathematics took place outside of class or away from the formal study of the subject. Consequently, they concluded that mathematics had always been a difficult subject to teach and to learn.

Student Diversity

In addition to the very nature of the subject matter, another contribution to the difficulty of specification of the best remedial program model for basic mathematics was the diversity of the students for whom the program was designed (Ponticelli, 1988:3). Hecht and Akst (1980:227) noted that students in remedial mathematics programs tended to be very heterogeneous.

> They vary enormously in almost every respect: socioeconomic status, academic background, self-image, study skills, age, goals, and orientation to college. Even with respect to their mathematical deficiencies, there may be a tremendous variation from one student to the next (Hecht and Akst, 1980:228).

Some basic mathematics students had difficulty with reading and writing as well as mathematics. They often had weak study habits, a poor self-image, diffused goals, unsuccessful learning experiences, and a dislike for mathematics (Friedlander, 1979:3; Ahrendt, 1987:1). Other students demonstrated some or all of these characteristics, but with respect to mathematics alone. They had college level skills in reading and writing. Many of these students simply considered themselves "dumb" in mathematics (Hecht and Akst, 1980:227). A third characteristic group of students had simply forgotten what they once knew or avoided studying mathematics for one reason or another. These students were adequately served by a quick review of the material they lacked, and did not need the slower paced and more detailed course required by the other groups of students (Hecht and Akst, 1980:227; Habib, 1981:4).

Appropriate Instructional Methods for Basic Mathematics Courses

A critical element in the design of any educational program was the selection of the most appropriate instructional methodologies. This designation was made difficult by the significant diversity of student characteristics described in the previous section. It was suggested from the literature review that with this diversity of student characteristics came the belief that there was no single best way to teach arithmetic in a community college setting. Because of differences in the cognitive styles of students, almost any method worked well with some students and not well with others. The goal of improving instruction by finding the single method or set of methods that would work for all students was unachievable (Cross, 1976:111).

Cross (1976:112) added that, under various teaching conditions, "some students improve, some remain unaffected, and a few actually regress." Following an analysis of community college developmental programs, Friedlander (1979:3) took the position, echoed by Woodfaulk (1982:15), that

> Universally successful teaching materials and methods are not available. The students who must be taught are so varied that any one set of procedures is doomed to fail for at least a number of them.

Program Flexibility -- Variety of Methods

Roueche (1984:23) recognized the extent of student diversity in American community colleges and saw flexibility as a key element in the success of remedial programs. This flexibility was best reflected in the availability of a variety of programs to accommodate the wide range of learner styles and differential learning rates possessed by students (Roueche and Pitman, 1972:39). Irish (1979:40) observed that developmental students needed to be able to pick and choose among alternative materials to find those with appealing formats as well as to provide a variety of practice opportunities. This acceptance of flexibility and adaptability may well have been the reason that many of the recent changes in educational methodology and thinking emanated from the community college (Lord, 1988:106).

Roueche and Snow (1977:8) argued that, due to the frequent lack of program flexibility, remedial education in the 1960s was largely ineffectual. Following a detailed study of a community college basic mathematics program in 1969, Dahlke (1975:188) concluded that many, if not most, such programs were not effective in helping students grasp the basics of arithmetic. Concern about the nature of basic mathematics programs in California community colleges during the 1960s was reflected in a study of arithmetic courses at these institutions by Kipps (1966). She observed that a rather limited variety of instructional styles were available to students. Primarily oral techniques and traditional instructor-paced formats were used in these classes (Kipps, 1966:107). Based on a ninety-three percent response rate in a survey of all 178 instructors teaching arithmetic during the day through junior college mathematics departments in California in the 1965 fall term, Kipps (1966:107) concluded that sixty-four percent used lectures, sixty-one percent used question-and-answer (questions by the student), and fifty-seven percent used discussion (question by the teacher) in the instruction of arithmetic. Programmed texts were used by twenty-seven percent of the instructors and six percent allowed students to proceed at their own rate (Kipps, 1966:107).

In a later national study, Baldwin (1975:16) observed greater use of individualized instruction and less use of lecture than reported by Kipps (1966:107). He also recorded the use of audio-tutorial and computer-aided instruction techniques in developmental mathematics courses. Neither of these techniques were available to students in California in

1965 according to the study by Kipps (1966). Baldwin's (1975) study of developmental mathematics courses was based on a survey of selected two- and four-year colleges in twenty-one states. Respondents were asked to list the instructional methods that best described the developmental mathematics courses at their college. Lecture, cited by fifty-five percent of the respondents, was used only slightly more than programmed instruction, which was noted by fifty-four percent of the respondents. Other methods used were: individual attention (forty-four percent), workbook or work sheets (twenty-nine percent), audio-tutorial (twenty-four percent), Keller plan (thirteen percent), and CAI (four percent).

A significant increase in the use of individualized instruction between the mid-1960s and mid-1970s was apparent from the studies by Kipps (1966) and Baldwin (1975). Cross (1976:11) found that a similar increase occurred on a national scale and reported that the number of colleges using programmed instruction increased between 1970 and 1974 from forty-four percent to seventy-four percent. Cross (1976:47) was so impressed with the efforts college instructors were making to add flexibility to their educational programs through individualized instruction and mastery learning techniques that she described the events of this period as an "instructional revolution." That faculty would rise to the occasion to meet the needs of students was not a surprise to Hecht and Akst (1980:234) who observed that the faculty would, if left to their own devices and given reasonable encouragement and administrative support, usually introduce "a variety of ingenious and effective techniques to enrich classroom instruction."

Individualized Instruction

The instructional revolution ushered in a major collegiate commitment to experimentation with alternative instructional techniques. As the number of developmental students in higher education increased so did the variety of methods used to assist their learning. Reported in the literature were the effects of various individualized instruction formats. These included using audio-tutorial materials, video-tutorial devices, audio-video-tutorial programs, computer-aided instruction, self-pacing, mastery learning,and programmed learning.

Lindberg (1976:15) found, in a survey of developmental mathematics programs, that the more successful used individualized instruction and mastery learning rather than lecture formats and traditional classroom organization. Dahlke (1975:187) stated that the individualized, self-paced instructional mode was ideally suited for those arithmetic students who needed only a brief review of the subject. Garrett (1987:2) felt the "chalk and talk" method of mathematics instruction had proved to be an inadequate solution to the remedial education problems of the vast majority of developmental students. Hassett and Thompson

(1978:762) concluded that individualized instruction is more effective than the traditional lecture approach in "an overwhelming majority of those published studies which meet generally accepted standards of statistical validity." Harris and Harris (1987:18) expressed the belief that often there were too many levels of intuitive understanding or lack of understanding for a teacher to explain or demonstrate an idea satisfactorily to each student in a group setting. Staff in the Office of the Chancellor of the California Community Colleges (1985:40) felt that in many instances self-paced, open-entry, open-exit courses were the most effective choices for developmental courses. The Washington State Board of Community College Education (1983:3) recommended that "flexible self-paced learning opportunities" that were based on mastery learning concepts be a required component of basic skills education in that state.

Because of the diversity of student backgrounds observed in the arithmetic classes at Bellevue Community College (WA), Habib (1981:4) suggested that it was fruitless to conduct the class as a single group. Instead, the course was individualized and self-paced to best accommodate the learning rates of the students and to provide for the opportunity of mastery. Thompson and McCoy (1979:217) found that instructor-pacing of an individualized instructional approach was a disaster for the lowest level course (beginning algebra) offered at the University of Arizona.

The extra pressure to keep up to a fixed paced simply exacerbated student anxiety and caused many to drop out.

Hecht and Akst (1980:23), as well as Steele, Legg, and Miles (1980:46), noted that the most serious difficulty with self-paced instruction was student procrastination. This problem was amplified for remedial students because many of them were neither self-disciplined nor highly motivated. In a description of the independent study program at Lane Community College (OR) using an open-entry/open-exit format with self-study texts, single concept video tapes, tutoring, and small group instruction, Fast (1980:1) reported that forty-six percent of the students failed to complete any course work. Rather than with innovative, personalized methods of instruction Maxwell (1980:381) believed that what matters most in improving the learning of underprepared students "is the amount of time they spend in direct structured learning situations, and the skills of their teachers."

Mastery Learning

Mastery learning referred to the pedagogical concept that learning be thorough. The student learned each topic sequentially and demonstrated that knowledge at a high level of competency before the next topic in the sequence was attempted (Cross, 1976:77).

Cohen and Brawer (1982:245) reported that classes organized around the concept of mastery learning exhibited superior student achievement and retention. These levels exceeded those reached in other remedial courses and those reached in regular college courses not using mastery learning as well. The Committee on the Undergraduate Program in Mathematics (1982:269) of the Mathematical Association of America felt that topic mastery should be required of students no matter the number of attempts needed to show it, within limits.

Support for mastery learning was not universal. Chisko (1985:592) felt the emphasis on mastery focused arithmetic courses on computational skill development where mastery was easy to define and test rather than on the concepts needed most to support the processes of mathematical thinking. Maxwell (1980:380) asserted that

> courses for underprepared students taught with mastery learning methods have yielded more failures than success, and there is little convincing evidence to support the contention of those experts who travel around the country lecturing that the lecture method should be replaced by individual instruction . . . .

She argued that evaluations of students who had done well in classes organized around the concept of mastery learning revealed that they would have succeeded in traditional lecture classes.

Lecture Method -- Traditional Class Structure

The traditional lecture method was not without support among those with developmental education experience. Hecht and Akst (1980:233) felt that conventional classroom instruction worked as well in remedial programs as in college level courses. Clute (1984:56) reasoned that the lecture method was better for highly anxious students with little confidence in their own methods of mastering the material, because they relied heavily on a well-structure, controlled plan for learning. Although she stressed the need for an individualized approach to help adult learners cope with potential barriers to completing course work, Kelly (1986:12) noted that developmental students had a strong preference for a structured rather than independent learning environment. Following a study of ten thousand developmental students spread over twenty colleges in fourteen states, Warren (1985:71) reported that, by a margin of two to one, students preferred clearly structured classes. Bittinger (1971:456) observed that many remedial students responded well to a lecture approach because they needed to "see the instructor do it." Mitchell (1980:46) characterized individualized study as only an alternative to the lecture class. She found that some students needed the structure inherent in such a class and observed a success rate essentially equivalent for the two modes of instruction. Alberding (1983:1) did not see the lecture method as inherently inappropriate. He felt, as did Spangler (1978:11), that a lecture component was a necessary part of an individualized program (Alberding, 1983:20).

In describing the arithmetic program offered at the University of Minnesota in the early 1970s, Robertson (1983:5) characterized it as based on a semi-programmed textbook and audio tapes. The majority of students were only marginally successful. An experimental lecture class was introduced. It was found that this format was more effective for some students while the original programmed class was more effective for others. A second phase of this research study was initiated. The purpose of this later phase was to test the feasibility of matching individual learning styles with the variety of instructional methods available. Although methods for such matching were found, Robertson (1983:5) concluded that they were impractical because of the excessive amount of pretesting necessary before these methods could be used. Further, Robertson (1983:5) found that, in those cases where student characteristics were ignored, students who took lecture sections were more successful that those who took programmed class sections. The decision not to expand the effort and match cognitive styles to instruction technique was supported by Cross (1976:26) who felt that cognitive style matching was not always in the best interest of the student.

Eclectic Approach

Developmental mathematics classes were not required to conform to any particular format. The instructors were not limited to a choice between the lecture format and one developed around student self-pacing (Roueche, 1984:24). Friedlander (1979:4) suggested that, in the face of diverse student learning characteristics, a more effective approach to presenting developmental mathematics was to use a variety of learning techniques. This allowed the advantages of lectures to be combined with the strengths of "controlled, self-pace instruction" (Friedlander, 1979:4). Keimig (1983:40) also recommended this approach and observed that "eclectic instruction works best." She felt such a format provided a balanced combination of individualized laboratory practice and class interaction. Cohen (1987:9), Pearlman (1977:9), and Maxwell (1980:382) also supported the eclectic approach.

An application of this technique was apparent in the Fresno City College (CA) developmental skills committee recommendation that the basic mathematics class be offered as a lecture/laboratory combination rather than as a purely lecture course (Cramer and Liberty, 1981:15). The committee felt it important that these students learn how to learn in a lecture format because this was the format of more advanced classes. However, since they were still learning how to learn, these students required the directed, supervised study opportunity a laboratory environment provided. Petricig (1988:385) described a course format in which a laboratory component was integrated into a collegiate remedial mathematics program although the institution was strongly committed to the lecture approach. In addition to lecture attendance, students were required to regularly take a homework assignment to the mathematics learning center for review with the laboratory instructor or aide. Over the four year period for which an evaluation of this laboratory activity was conducted, those students enrolled in class sections taught by instructors using the laboratory component achieved higher final course grades than those students without this opportunity. Attrition was ten percent lower in those classes with access to the laboratory experience.

Computer-Aided Instruction

A significant instructional technology that developed in the last decade was computer-aided instruction. Though manifested in many forms, it relied on the speed of modern digital computers to generated appropriate learning experiences for developmental mathematics students. It was often an interactive mode of individualized instruction, but rarely the sole means of instruction available to the student. Capps(1984:4) strongly recommended CAI practice units offered by the mathematics laboratory supporting the arithmetic course at Somerset County College (NJ). A similar lecture/CAI laboratory technique was implemented at De Anza College (CA). The pre-algebra course was organized around lectures that were given to groups of 120 students. These lectures were augmented by closely monitored laboratories, in which the computer acted as tutor and skill builder (Avery, 1985:3).

Barker (1987) identified several positive aspects to the De Anza College approach with CAI. (1) Students were converted from passive to active learners. (2) Learning came from peers as well as the instructional staff. (3) Greater personal communication between the instructor and student was encouraged. (4) The instructor was more efficient in the classroom. Students who generally would not go to the instructor's office for help did go to the laboratory to resolve difficulties. Consequently, these students were better prepared when they attended the large lecture sessions. (5) The student themselves set high mastery levels. (6) From an administrative standpoint, productivity was increased through the success of the large class format. These positive observations were consistent with Orr's findings at Crafton Hills College (CA) that when a traditional lecture presentation in an arithmetic course was supplemented with CAI, student performance was greatly improved ("Study Proves CAI Effective in College Math Course," 1982:9).

The observation by Harris and Harris (1987:18) that CAI was a tool that reduced anxieties was important, because many developmental mathematics students suffered from math anxiety and low self-image (Ahrendt, 1987:1). The two authors felt this reduction in anxiety occurred because computers: (1) had infinite patience, (2) never became tired, (3) never were frustrated or angry, (4) never forgot to correct or praise, and (5) individualized. Hecht and Akst (1980:244) noted that, to many remedial students, the computer represented the complexity of twentieth century technology. Consequently, these students were often very gratified simply through successful communication with the computer. Because it was responsive, tireless, and accurate, Hecht and Akst (1980:244) suggested that the computer may well become the ultimate tool for individualizing drill-and-practice exercises in mathematics.

Bozeman (1986:12), based on a review of the literature related to instructional effectiveness of computer technology, suggested that programs supplemented with CAI were at least as effective, and frequently more effective, than instructional programs that used only traditional instruction methods. Myers (1983:5) reported that those remedial educators who used CAI did not recommend replacing teachers with computers. Rather, they considered CAI as an instructional technique that worked well with some students. Encouragement of this particular instructional tool was given by Maurer (1986:10) who noted that computing was the only technology for assisting learning that was currently declining rapidly in cost. In fact, he saw all others as increasing. He estimated that by the mid-1990s, computer costs will have declined by a factor of ten while equipment capabilities will have increased.

Other Instructional Technologies

CAI was not the only instructional technology that was used to supplement basic mathematics at the postsecondary level, although the technology had developed most rapidly in the 1980s. Programmed texts, audio-tutorial materials, and video-tutorial techniques were also well developed and respected tools.

Programmed texts and programmed learning were developed to allow students to pass quickly over material already known or quickly learned, and to support learning in greater detail in those areas with which the student had more difficulty (Cross, 1976:50). This was an early format for individualized instruction. Kipps(1966:107) found that twenty-seven percent of arithmetic instructors offering arithmetic during the day through mathematics departments in California community colleges used such materials. In the mid-1970s Baldwin (1975:16) observed that the use of this technique was comparable to that of the lecture format in developmental mathematics courses.

Audio-tutorial and video-tutorial techniques emerged in the 1960s (Cross, 1976:50). With this format, audio taped or video taped lectures or explanations were used by students to support the material presented in the textbook or workbook. It was primarily through the use of these techniques that many individualized, self-paced, open-entry/open-exit developmental mathematics learning environments were created in the 1970s. Baldwin (1975:16) found, during his study of the developmental mathematics programs in selected two- and four-year colleges in twenty-one states, that twenty-four percent of the programs made significant use of audio-tutorial technology. Baley (1981:6) and Garrett (1987:2) noted that while audio-tutorial technology was popular with teachers, students were far less impressed. Students generally preferred simply to read the text than to take the time to follow along in the textbook in conjunction with the taped lesson. Capps (1984:4) observed that the audio/visual materials available in the mathematics laboratory at Somerset County College (NJ) were under utilized. Miller and McDermott (1983:175) concluded that students made greater use of taped lessons when variable-speed machines were used. This allowed students to proceed through them at exactly their desired speed. Alberding (1983:34) noted that, although the tapes were not greatly used by students, the presence of these materials provided some psychological support to the student. He recommended that the taped lessons be kept available for student use.

Many of the comments concerning individualized instruction presented in an earlier section of this MARP applied equally well to the audio-tutorial and video-tutorial technologies. While successful in some situations with some students, not surprisingly, this technology failed to adequately serve many students (Cross, 1976:88-89).

A new technology was reported to be appearing on the horizon. This was the integration of computer and videodisc technologies. Because of the success of this integration, the possibility existed for inexpensive interactive video courseware in the near future (Wisconsin Foundation for Vocational, Technical, and Adult Education:1988). If development occurs, this technology will make available another powerful tool in the educational arsenal for the support of student learning in developmental mathematics.

Summary of Instructional Methods

The opinions of authors who identified the most appropriate instructional methods for developmental students were often in opposition. For any strong opinion that supported a particular single instructional style there existed an equally forceful contradictory view. This situation was not unexpected. No method was perfect and no method was an absolute failure. Roueche (1984:23) saw flexibility as a key element in the success of remedial programs. The literature underscored this observation. One was not defeated by the specter of "Snow's Law" (Maxwell, 1980:389): "No matter how you try to make an instructional treatment better for someone, you will make it worse for someone else . . . ." (Snow, 1976:292). Flexibility was the key. One simply used what was most successful at that moment, with those students, and for the particular instructor. When what worked for one student was kept and other students were allowed to choose a different instructional style, all were better served.

Not all developmental program components produced such divergent views as were present in the area of instructional methods. Such topics as the importance of developmental mathematics instructors and support service components had a fairly clear consensus in the literature.

Opinions related to the topics of program organization and course content had only a amount of minimal variation.

Remedial Mathematics Instructors

Recognition of the key role played by the instructors in developmental mathematics courses was essentially universal in the literature. Maxwell (1980:380) argued that the skills of the teacher were among those factors that mattered most in improving learning by remedial students. Jorgensen (1981:170) concluded that the personalized contact between instructor and student was the common denominator for success. This was true whether a lecture or individualized instruction technique was used. For Roueche (1968:18) the teacher was, without question, the most important element in the success of remedial programs. He concluded that teacher expectations were a key factor in the design of learning environments for developmental students (Roueche, 1976:48). Roueche also noted that a quarter of the students in a class would fail if the teacher thought they should, no matter what instructional method was used (Roueche, 1976:48). Kipps (1966-1967:40) found that favorable attitudes of the instructors toward teaching arithmetic classes resulted in higher student achievement.

Carbone (1987:26) reported that poor student academic performance stemmed as often from poor teaching as from poor skill development. Strowbridge (1987:96) was unequivocal in his belief that the teacher was the key to successful learning in mathematics. Beckwith (1980:55), Friedlander (1979:5), Harris and Harris (1987:20), and Myers (1983:4) expressed a similar position. Consequently, it was not surprising that these authors strongly recommended that only skilled instructors who volunteered to teach developmental classes be so assigned. Grant and Hoeger (1978:20) noted that the common practice of staffing remedial courses with inexperienced or part-time instructors was based on a misunderstanding of the talents necessary to teach basic skills. They feel that "basic skills courses are the most difficult courses to teach in all of postsecondary education." The Board of Directors of the American Association of Community, Technical and Junior Colleges noted that faculty and staff assignments in successful developmental programs were limited to those who were confident in their ability to cause learning ("Access, Assessment, and Developmental Education," 1987:40).

Instructional Support Services

In addition to the assignment of an instructor, a mathematics student often had access to supplemental instructional support services such as: assessment testing, counseling, learning centers, mediated instructional materials and devices, study sessions, tutoring, and workshops. These elements added flexibility to the basic mathematics program because the student was often free to choose between those services available and the ones that were most helpful. Some students felt more comfortable with a particular set of services while other students chose different supplemental learning opportunities. These services represented an extension of the teacher, and allowed more students to be helped than possible with only one-to-one contact between teacher and pupil.

Tutors

The value of tutoring in remedial programs was an area of consensus in the literature. This agreement made it safe to assume that tutoring was an important element in successful remedial programs (Roueche, 1984:23).

In his national study of remedial mathematics programs in public two-year colleges, Jorgensen (1981:131) found that tutors were available to students in sixty-three percent of these institutions. Baldwin (1975:29) found, in a study of remedial mathematics programs in selected two- and four-year colleges in twenty-one states, that peer tutoring at two-year colleges was very popular. Hecht and Akst (1980:237) stated their position clearly. "To the remedial instructor, no resource is more valuable than a competent tutor." Abraham (1986), Alberding (1983:46), Barshis (1984:5), Bohr (1983:4), Campbell (1983:5), Committee on the Undergraduate Program in Mathematics (1982:269), Donovan (1985:108), Morris (1981:416), Myers (1983:5), Opp and Colby (1986:3), Roueche and Kirk (1973:67), Roueche and Snow (1977:96), Starks (1984:1), and Yawin (1981:9) all attested to the value of the service provided to remedial students by peer tutors. Maxwell (1980:383) reported that peer tutoring was the most popular technique for aiding the underprepared student in both skills and subject matter area. She noted that students were often more comfortable with peer tutors than with the actual course instructor (Maxwell, 1980:384). Wepner (1985:165) believed that it had become a generally accepted practice to include tutors as an integral part of the remediation process in mathematics. Rounds (1984:1) agreed that this was the case for California community colleges. Carman (1974:35) found that the opportunity for supplemental tutoring of arithmetic students at Santa Barbara City College (CA) significantly reduced student attrition and promoted a more positive attitude toward mathematics. Carman (1974:38) recommended that tutoring be a central component in any college developmental mathematics program. In the study by Patterson and Sallee (1986:725) of successful college and university remediation programs in California, every program described relied on student tutors/assistants to some degree.

Mathematics Learning Centers

Mathematics learning centers were places where students often came to meet with tutors, study with friends, take advantage of mediated instruction and practice opportunities, or seek counseling and advice. In general they were applied learning laboratories, the primary purpose of which was to promote student learning.

Some years ago, Kipps (1966:73) found that seven California public junior colleges operated mathematics laboratories or skills centers in the mid-1960s. A key element in the more recent "instructional revolution" (Cross, 1976:11) was the growth of skills centers at the college level. Such centers spread from thirty-six percent of the colleges nationally in 1970 to sixty-seven percent of the colleges in 1974 (Cross, 1976:11). Jorgensen (1981:131) noted that laboratories were used by forty-two percent of the public two-year colleges included in his national study of remedial mathematics programs. Alberding (1983:37) looked for existence nationally of mathematics learning centers without regard to their use in developmental courses. He surveyed all 1230 community, junior, and technical colleges that were operational in 1980 and received responses from 720 (fifty-nine percent) of the total population. Because 524 of the responding colleges operated mathematics learning centers, he concluded that seventy-three percent of the two-year colleges, nationally, operated mathematics learning centers on their campuses.

Although tutoring took place in a variety of settings, Campbell (1983:5) recognized tutoring as the most important and most often discussed role of the college learning center. This was supported by the observations of Roueche and Snow (1977:91). Alberding (1980:105), in his national survey, found that tutoring was the most essential service provided by two-year college mathematics learning centers. This service was important to students enrolled in college level courses as well as those participating in developmental programs. Hecht and Akst (1980:230) gave clear support for the use of mathematics laboratories. They asserted that "a well run lab can be all things to all people." This, they felt was true, regardless of the method of instruction used (Hecht and Akst, 1980:256) and further noted that even the simplest mathematics laboratory, staffed by tutors and open for only a few hours a day, made an enormous difference to the remedial mathematics program. They argued that the learning center experience was especially valuable if the program used conventional classroom instruction. Of course, tutoring was not the only service provided in these centers.

Spangler (1978:3) saw, in the mathematics laboratory, a means of meeting the individual needs of students. Alberding (1983:2) listed among the services appropriate for the mathematics learning center a variety of individualized experiences including: computer-aided instruction, counseling, testing, tutoring, and the availability of calculators, reference books, and audio-visual materials. Mitchell (1980:43) stressed the role of the mathematics learning center at Pima Community College (AZ) in the destigmatization of remediation. In the center, remedial and college level studies occurred side-by-side with no distinction. Wong (1982:48) made a similar observation concerning a proposed developmental learning facility at East

Los Angeles College (CA). Beckwith (1980:27) noted that although the use of mathematics learning centers was not limited to remedial courses, it appeared from the literature that they were both needed most and utilized most in that portion of the mathematics curriculum. Africk (1984:3) found that use of an open or walk-in learning center format increased retention in the mathematics classes. McAllister, Stroup, and Martin (1987:15) determined that most developmental students did not have the self-discipline to attend the learning center on a drop-in basis and recommended that a regular time for student attendance be scheduled.

Basic Mathematics Course Content

Only in a few instances did the literature address the specific topics appropriate for inclusion in the basic mathematics courses. Dahlke (1975:181) felt the general course objectives should be limited to student mastery of the four basic operations on whole numbers, fractions, decimals, and the basic concepts of percent. Hecht and Akst (1980:219) reported that all arithmetic courses at the member institutions of the City University of New York covered operations with whole numbers, fractions, and decimals. Other topics included in some courses, but not others, were ratio and proportion, percent, word problems, operations with signed numbers, and a study of measurement. The program offered at Butte College (CA) included whole numbers, fractions, percentage, signed numbers, measurement, and selected elementary algebra topics (Evaluation of Remedial Programs: Pilot Study Final Report, 1985:32).

In a study of arithmetic courses offered during the day through mathematics departments in public California junior colleges in the 1965 fall term, Kipps (1966:103) found operations with fractions and decimals in all arithmetic courses offered by the 165 (N=178) responding instructors. Ratios and proportions were included by ninety-eight percent of these teachers. Operations with whole numbers and the topic of estimation were each taught by ninety-three percent of the instructors.

The following material had the indicated coverage among the 165 responding instructors: measurement (ninety percent), formulas (ninety percent), percentage (eight-seven percent), denominate numbers (eighty-seven percent), factors and prime numbers (eighty-six percent), axioms and properties of operations (sixty-seven percent), and inequalities and sets (thirty-nine percent). Although it did not suggest specific topics for inclusion in the college arithmetic course, the Committee on the Undergraduate Program in Mathematics (1982:268) of the Mathematical Association of America was clear in its demand that the remedial course not be a "mere rehash" of the traditional primary or secondary course.

> Students should be able to find even remedial courses fresh, interesting, and significant . . . . Games, problems of obvious everyday interest, opportunities for creativity, an occasional attention to general-problem-solving strategies should contribute to a cheerful and

> progressive atmosphere and a positive experience (Committee for the Undergraduate Program in Mathematics, 1982:268).

Structure of the Basic Mathematics Program

The literature provided little information concerning how the postsecondary basic mathematics program should be organized into courses, and how much credit the student should be given for these experiences. Crepin (1982:7) described the organization of the pre-algebra program at Lower Columbia College (WA). At LCC three courses existed below the beginning algebra level. The most elementary course was set at the first grade level. A basic arithmetic course called Review of Mathematics was offered. This was followed by a bridge course to beginning algebra called Algebraic Concepts. These three courses were paralleled by a one unit Math Anxiety Workshop.

The LCC program organization was in contrast to the reports by Mitchell (1980) and Kipps (1966). Mitchell (1980:43) noted that the downtown campus of Pima Community College in Tucson (AZ), offered only a single three unit arithmetic course prior to enrollment in beginning algebra. A review of California junior college program patterns used in the 1965 fall term was completed by Kipps (1966). At the time of her study, seventy-three public junior colleges were existent Sixty-two schools offered an arithmetic course or courses through the mathematics department. Of these colleges, eight offered two courses. The author did not indicate whether these course pairs were of a sequential or parallel nature (Kipps, 1966:155). Of the eleven California junior colleges where arithmetic was not offered through the mathematics department, two schools (Cuesta College and Rio Hondo College) had recently been opened and an arithmetic course was not part of the curriculum. The remaining nine schools offered an arithmetic course through a department other than mathematics. For example, Sierra College offered the arithmetic course through the forestry department.

Akst (1985:151) believed that the developmental mathematics program must be responsive to the diverse needs of students requiring mathematics remediation in community colleges. He recommended that an intensive course be available for the very weak student and a briefer arithmetic course be available for the student in need of only a quick review. He added that these courses should have sufficient contact hours to allow skill development and practice during class time. For this reason, Akst (1985:152) recommended that the arithmetic course be scheduled to meet at least four hours each week.

Administrative Jurisdiction Over the Remedial Mathematics Program

The placement of the remedial mathematics program within the college organizational framework was of concern to several authors. Primarily the choice was between placing it under the jurisdiction of the mathematics department or in a separate department of remedial or developmental skills (Hecht and Akst, 1980:253). Roueche, Kirk, Snow, and Cross strongly supported the separate department structure for the remedial program (Roueche and Kirk, 1973; Roueche and Snow, 1977; Cross, 1974). With this structure they felt that an integrated team of specialists would be available to offer a complete set of services for the developmental student. Cohen and Brawer (1982:233) believed that the most prominent development in remedial education in the 1970s was the "integrated program combining instruction in the three Rs with special attention to individual students."

Several authors, including Richardson, Fisk, and Okun (1983:165), Hecht and Akst (1980:253), Leitzel (1985:186), were openly opposed to the placement of the mathematics remediation effort anywhere but within the mathematics department. To do otherwise insured, they felt, discontinuities between remedial and college level courses in mathematics. Further, they argued, that such an organization invited a polarization between the developmental faculty and "regular" mathematics staff. They noted that not all remedial mathematics students were in need of the services of a "community of learning specialists," and felt such students would not want to be associated with an explicitly remedial department. Keimig (1983:15) noted that successful remedial programs were "integrated into the academic and social mainstream" and thus avoided student exposure to the low status connotations often associated with participation in a separate remedial administrative component. Rotman (1987:4) speculated that, nationally, the vast majority of developmental mathematics programs were located in the mathematics department.

Summary of the Review of Related Literature

It was clear from the review of the literature that every community college had need for a quality basic mathematics program. For the goal of quality to be achieved,, the program had to be flexible Only in this way did the program respond adequately to the multitude of learning styles students brought with them to the two-year college environment. While some students excelled in individualized self-pace or independent study environments, other students hopelessly floundered with such freedom. Many students needed the structure and group identity provided by a lecture class, but such classes were strengthened by student access to a mathematics learning center or laboratory. These centers often provided tutorial and mediated instructional support services. The key to it all was quality instruction. This was provided, directed or supported by quality teachers and learning assistance supervisors.

The literature was mixed concerning the administrative organization of the developmental mathematics program. The mathematics literature supported placement under the jurisdiction of the mathematics department. The developmental education authors sought its containment within a separate developmental skills organization. Less controversy surrounded the content of the program itself. This reaction might have resulted partially from the fact that the literature contained few references in this area. The only significant issues discussed related to the number of courses in the program, the division of subject material between the available courses, and the appropriate number of class contact hours.

A sound base for the development of the Saddleback College program was insured through supplementation of the rather limited literature related to the last three topics: the number of courses in the program, the division of subject material between the available courses, and the appropriate number of class contact hours. The curriculum literature of the California community colleges was studied to determine the trends in these areas. The process for this review, as well as the rest of the methodology for the research effort of this MARP, was described in the next chapter.

Chapter 3

PROCEDURES AND METHODOLOGY

The research effort conducted for this case study involved several distinct components. A review of curriculum literature, a survey of a complete population, the statistical test of several research hypotheses based on random samples from two target populations, and a group decision technique were efficiently and effectively integrated to meet the purpose of the study. A review of the catalog and announcement of courses were used to gather information concerning the content and organization of the basic mathematics program at each California community college.

To provide the data necessary for an analysis of the learning environments available to community college basic mathematics students, a survey of the mathematics department chairpersons of these colleges was conducted. As a means of determining whether demographic differences existed between the population of basic mathematics students and the population of algebra students at Saddleback College, a random sample of one hundred students was chosen from each population. Statistics related to the research hypotheses were calculated for both samples and the statistical significance of the differences were tested. A Delphi exercise was conducted with the Saddleback College mathematics faculty as the respondent group. This exercise produced the information necessary to specify the most appropriate basic mathematics program at Saddleback College.

Review of Curriculum Literature

A review of the basic mathematics curricula of the California community colleges was conducted using the program descriptions contained in the current college catalog and announcement of courses current for the 1988 fall term published by each college. The use of catalogs to determine the content of college programs was a technique used by Roueche and Kirk (1973:13) in a study of community college remedial programs and by Beckwith (1980:28) in a study of community college mathematics programs. Catalogs of fifty-five California community colleges were available for study in the Saddleback College Career Guidance Center. Of the remaining fifty-one colleges, current catalogs for twenty-four were available in microfiche form from the Microfiche College Catalog Collection produced by the Career Guidance Foundation.

This collection was part of the research holdings of the main library at the University of California, Irvine. Neither of these sources had current catalogs available for twenty-six schools. However, catalogs that were no more than two years old were available. Each of the twenty-six colleges was contacted by phone. The individual reached, usually in the counseling office, was asked to described the basic mathematics program by reading the contents of the current catalog in this area. Changes were noted from the older catalog descriptions previously obtained and this edited edition was treated as the current catalog from that school. The information gathered in this college catalog review was used to answer research question 1: "What organizational patterns for basic mathematics courses and programs were used in the community colleges in California?"

A national perspective on basic mathematics programs at the two-year college level was gained through an exhaustive review of the mathematics education, developmental education, and general education literature. These sources were located through the Education Index, Dissertation Abstracts, Educational Resources Information Center (ERIC) system, and professional colleagues. It was upon these sources that the review of related literature of chapter 2 was based.

Basic Mathematics Learning Environments Available in the California Community Colleges

A survey of the mathematics department chairpersons of the 105 degree granting California community college was conducted to provide the data base necessary to answer research question 2: "What learning environments were available to students in the basic mathematics programs of the California community colleges." Such surveys have been the primary method of gaining specific information about collegiate developmental mathematics programs and was the methodology adopted by Kipps (1966), Beal (1970), Baldwin (1975), Beckwith (1980), Jorgensen (1981), Chang (1983), and Akst and Ryzewic (1985). A brief questionnaire dealing with the learning environments available to students in basic mathematics courses was mailed to each of these community college educators. They were asked to return the completed questionnaire by mail.

Population

There were seventy individual community college districts in California overseeing the operation of 106 community colleges in the 1988 spring and fall terms. The San Francisco Community College District was one of nineteen multi-college districts and was composed of two colleges: (1) City College of San Francisco, (2) San Francisco Community Colleges Centers. Each of these two colleges represented a distinct educational delivery system and mission (San Francisco Community College District, 1986:35). The City College offered a credit curriculum leading to the Associate of Arts degree, certificates, and transfer to four-year institutions. The Centers focused on noncredit offerings with particular emphasis upon vocational education leading to employment or job up-grading, English as a second language, elementary and secondary basic skills, parent education, older adults, health and safety, the disabled, home economics, and citizenship for immigrants. The Centers were, and still are, unique in California as the only non-degree granting community college. Their mission was, however, not unique. It conformed closely to the mission of the San Diego Educational Cultural Complex that was part of the San Diego Community College District. The complex, however, was not recognized as a separate college.

This major applied research project revolved around the need to identify educational environments appropriate for students seeking an associate degree or transfer to a four-year college or university. Because these were not part of the mission of the Centers, it was decided not to include the San Francisco Community College Centers in the population for this survey. The total population size was 105 for the survey of the associate degree granting California community colleges.

Questionnaire Development

A brief survey instrument was constructed, using the basic mathematics learning environments identified in the review of the literature and the review of the catalogs of the California community colleges. This questionnaire was designed to fit on one side of a pre-addressed, postage paid post card. The format was designed so each respondent had only to check off those environments available to basic mathematics students at their college. A cover letter explaining the purpose of the survey was written to accompany the questionnaire. A directions page contained an explanation of the procedures necessary to complete the questionnaire and defined certain terms that might have been unfamiliar to the respondent. These documents were reviewed for clarity by four members of the Saddleback College mathematics department. It was suggested that the definitions of additional terms be included on the directions page. Further, it was suggested that the phraseology on a portion of the questionnaire be modified. These changes were made and the revised documents again reviewed by the same four members of the Saddleback College mathematics faculty. The faculty found the cover letter, directions page, and questionnaire acceptable for use in the pilot phase of the questionnaire development. Examples of these documents were displayed in Appendix A, although the questionnaire was actually reduced seventy-seven percent from what was shown there so it fit on one side of a post card with dimensions four inches by six inches.

The questionnaire, cover letter, and directions page were sent to the mathematics department chairperson at six community colleges in Orange County (CA). These colleges were: Cypress College, Fullerton College, Golden West College, Irvine Valley College, Orange Coast College, Rancho Santiago College. In a handwritten greeting, these colleagues were told that this was a pilot phase of the survey and that, in addition to completion of the questionnaire, any comments that would improve the reader's understanding of the questionnaire items would be gratefully received.

Completed questionnaires were received from each of the pilot colleges though not always from the department chairperson. In four cases the questionnaire had been passed on to a faculty member with a particular interest in basic mathematics, as suggested by the survey cover letter. The suggested modifications to the questionnaire were reviewed. Those suggestions appropriate for the purpose of the current study were incorporated. The survey documents were then in the final form and ready for statewide distribution. Examples of the final version of the cover letter, directions page, and questionnaire were placed in Appendix B.

Because the possibility existed that all three documents might not stay together as they were passed from the original questionnaire recipient to the respondent, the decision was made to photo-reduce the directions page to post card size and affix it, with rubber cement, to the questionnaire. This assured that whomever received the questionnaire also had the directions and definitions necessary to complete it. The respondent was advised to peel off the directions page before mailing the completed questionnaire.

Survey Administration

A cover letter, directions page, and attached questionnaire (covering one side of a pre-addressed, postage paid, post card with dimensions four inches by six inches) were mailed to the mathematics department chairperson for each of the 98 California community colleges not already surveyed. Those already surveyed were Saddleback College and the six colleges that participated in the pilot stage. In the cover letter was the request for a response within three weeks. The number of colleges responding was fifty-seven. Consequently, at that point the desired information was available from sixty-one percent of the population. Three weeks after the first questionnaire was distributed, a second cover letter, directions page and questionnaire were addressed to the "Developmental Mathematics Instructor" at each college from which a response had not yet been received. The number of colleges responding to this request was ten. At that point the desired information was available from seventy percent of the population.

A third cover letter, directions page, and questionnaire were mailed six weeks after the beginning of the survey effort. These again were addressed to the mathematics chairperson at each college from which a response had not yet been received. A request was made for a response within two and one-half months. The long response time was necessary because the questionnaire reached most colleges after the end of the 1988 spring term. There was no guarantee that the mathematics chairperson would be on campus during the 1988 summer session. The number of colleges that responded to the third request for survey participation was eight. The desired information was available from seventy-eight percent of the population.

Following the two and one-half month waiting period, an individual in the mathematics department office, or other appropriate instructional office, at each college from which a response had not yet been received was contacted by telephone. The person was asked to identify an appropriate faculty member for contact with respect to this study. In many cases the faculty member identified was the mathematics department chairperson. A fourth cover letter, directions page, and questionnaire were addressed to the individual identified by the telephone contact. A request was made for a response within two weeks. The number of colleges responding was ten. At that point the desired information was available from eighty-eight percent of the population.

At this point responses had been received from all but thirteen colleges. It was realized that it might not be possible to obtain responses from the entire population. The California Postsecondary Education Commission (1983:115), in a study of remedial programs in public postsecondary educational institutions in California, was not able to secure responses from five California community colleges. Peterson and Berg (1982:11) conducted a state survey for the Office of the Chancellor of the California Community Colleges to determine the extent and use of developmental courses for the associate degree and received responses from all but six colleges.

It was decided that an effort would be made to at least match the ninety-five percent response rate realized by the California Postsecondary Education Commission (1983:115). Representatives at the colleges from which no response had been received were again contacted by phone and the identity of other mathematics faculty who were be knowledgeable about the basic mathematics program sought. Attempts were made to contact these individuals by telephone. In those cases where this effort was unsuccessful, the instructors were sent a survey cover letter, directions page, and questionnaire. Slowly, the majority of the desired responses were received either by returned questionnaires (six colleges) or telephone interviews (five colleges).

At that point, the mathematics faculty at only two California community colleges remained listed as nonrespondents. In one case, the college operated only an outreach program and employed no full-time mathematics faculty. In the other case, the college employed a single full-time mathematics instructor. Based on further telephone interviews, the questionnaires were completed for the remaining two colleges.

The survey of community college basic mathematics learning environments concluded five and one-half months after its initiation with responses from one hundred percent of the population. The information gathered from this survey was used to answer research question 2: "What learning environments were available to students in the basic mathematics programs of the California community colleges?"

Comparison of Basic Mathematics and Algebra Student Demographics

Sample

A random sample of one hundred students from each of these populations was chosen to provide the data necessary to test the seven research hypotheses that compared the demographics of students enrolled for the 1988 spring term in Basic Mathematics (424 students) with those students enrolled for the same term in the Beginning or Intermediate Algebra courses (1158 students). To make the sample selections, roll sheets for all mathematics classes were obtained from the Office of the Dean of the Mathematics, Science, and Engineering Division. These roll sheets were filed in alphabetical order according to the instructor's last name. Within each instructor group, the roll sheets were filed by the class ticket number that was issued by the college records office and determined the sequence these classes were listed in the college schedule of classes. The roll sheets for Basic Mathematics, Beginning, and Intermediate Algebra were photo-copied in the order they were filed. The basic mathematics roll sheets were placed in one stack while the algebra roll sheets were put in another. Following the order in which they were copied, the pages of the basic mathematics roll sheets were numbered separately one through twelve, and the pages of the algebra role sheets numbered one through thirty-three.

The mathematics classes, represented by these two groups of roll sheets, were placed in a random order using a table of random numbers (Abramowitz and Stegun, 1970:992-995). Beginning with column three, row fifty-one because the exercise was started at 3:51 p.m., pairs of numbers were read horizontally from the table. The numbered roll sheets were put in the same order as the occurrence of the associated sequence number from the table of random numbers. This exercise was completed first for the basic mathematics classes and then continued for the algebra classes. The roll sheets in each group were taped together, beginning to end, forming one long roll sheet for each group. The students were numbered, according to their position, sequentially from one to 424 or one to 1158 depending on the group.

Returning to the random number table at the point where it had been left, numbers were read in groups of three digits (triples). This was done repeatedly until one hundred different natural numbers less than 425 had been selected. The students from the basic mathematics list with these position numbers constituted the random sample of one hundred students from that group. The process was continued, but numbers were read in groups of four (quadruples). This was done repeatedly until one hundred different natural numbers less than 1159 had been selected. The students from the algebra list with these position numbers constituted the sample of one hundred students.

A request was made of the Dean of Admissions and Records for the following information concerning each of the students' in the samples: (1) age, (2) number of units completed at Saddleback College, (3) the grade point average at Saddleback College, (4) sex, and (5) ethnicity. Permission to receive this information was granted by the Dean and the data were provided by a senior research associate from the district management information systems department. After receipt of these data, the following information was calculated for both samples separately: (1) mean age, (2) mean number of units completed at Saddleback College, (3) mean grade point average at Saddleback College, (4) proportion of students with no units completed at Saddleback College, (5) sex distribution, (6) proportion of white, not Hispanic students, and (7) ethnic distribution. This information was sufficient to allow each of the seven research hypotheses to be tested.

Research hypotheses 1, 2, and 3 were tested using a two-tailed large sample z-test for the difference between two population means at the 0.05 level of significance (Mendenhall, 1983:306). This level of significance was chosen because of a desire to protect uniformly against either accepting the null hypotheses when they were false or rejecting them when they were true. The research hypotheses were:

$(H_o)_1$: There was no significant difference in the mean age between those students enrolled in Basic Mathematics and those students enrolled in Beginning or Intermediate Algebra.

$(H_a)_1$: There was a significant difference in the mean age between those students enrolled in Basic Mathematics and those students enrolled in Beginning or Intermediate Algebra.

$(H_o)_2$: There was no significant difference in the mean number of units completed at Saddleback College between those students enrolled in Basic Mathematics with more that zero units completed and those students enrolled in Beginning or Intermediate Algebra with more than zero units completed.

$(H_a)_2$: There was a significant difference in the mean number of units completed at Saddleback College between those students enrolled in Basic Mathematics with more that zero units completed and those students enrolled in Beginning or Intermediate Algebra with more than zero units completed.

$(H_o)3$: There was no significant difference in the mean grade point average at Saddleback College between those students enrolled in Basic Mathematics and those students enrolled in Beginning or Intermediate Algebra.

$(H_a)3$: There was a significant difference in the mean grade point average at Saddleback College between those students enrolled in Basic Mathematics and those students enrolled in Beginning or Intermediate Algebra.

Research hypotheses 4, 5, and 6 were tested using a two-tailed large sample z-test for the difference between two population proportions at the 0.05 level of significance (Mendenhall, 1983:315). This level of significance was chosen because of a desire to protect uniformly against either accepting the null hypotheses when they were false or rejecting them when they were true. The research hypotheses were:

$(H_o)4$: There was no significant difference between the proportion of students with no units completed at Saddleback College and enrolled in Basic Mathematics with such students enrolled in Beginning or Intermediate Algebra.

$(H_a)_4$: There was a significant difference between the proportion of students with no units completed at Saddleback College and enrolled in Basic Mathematics with such students enrolled in Beginning or Intermediate Algebra.

$(H_o)_5$: There was no significant difference between the sex distribution of students enrolled in Basic Mathematics and the sex distribution of students enrolled in Beginning or Intermediate Algebra.

$(H_a)_5$: There was a significant difference between the sex distribution of students enrolled in Basic Mathematics and the sex distribution of students enrolled in Beginning or Intermediate Algebra.

$(H_o)_6$: There was no significant difference between the proportion of white, not Hispanic students enrolled in Basic Mathematics with the proportion of such students enrolled in Beginning or Intermediate Algebra.

$(H_a)_6$: There was no significant difference between the proportion of white, not Hispanic students enrolled in Basic Mathematics with the proportion of such students enrolled in Beginning or Intermediate Algebra.

Research hypothesis 7 was tested using the chi-square test for the difference between several population proportions at the 0.05 level of significance (Byrkit, 1980:282). This level of significance was chosen because of a desire to protect uniformly against either accepting the null hypothesis when it was false or rejecting it when it was true. The research hypotheses were:

$(H_o)_7$: There was no significant difference between the ethnic distribution of students enrolled in Basic Mathematics and the ethnic distribution of students enrolled in Beginning or Intermediate Algebra.

$(H_a)_7$: There was a significant difference between the ethnic distribution of students enrolled in Basic Mathematics and the ethnic distribution of students enrolled in Beginning or Intermediate Algebra.

Recommendations for Improving the Basic Mathematics Program at Saddleback College

The set of recommendations for the basic mathematics program at Saddleback College was developed through the execution of a conventional Delphi exercise As described by Turoff (1975:84), the conventional Delphi exercise is a group decision technique used to identify important issues and approach consensuses among the participants through the use of a sequence of questionnaires. The members of the group do not meet face-to-face. In fact, one of the major attributes of this technique is that dominate personalities are prevented from influencing other participants as might occur in such a meeting. The exercise requires a monitor team and a respondent group. The monitor team prepares the questionnaires and tabulates the results. The respondent group reads the results summaries prepared by the monitor team and completes the questionnaires. After completing the questionnaire and given knowledge of the responses from the entire group, each member of the respondent group is given the opportunity to reevaluate their previous judgments and to address new items recommended by other participants. This process is repeated until further convergence of the group position is unlikely or until the critical issues have been sufficiently defined.

The Delphi exercise was chosen for this MARP primarily because it was difficult for the mathematics faculty to meet frequently as an entire group to discuss issues of mutual concern. It was felt to be an appropriate technique, based on the observation by Linstone and Turoff (1975:5), that the Delphi exercise was a well-developed tool in college curriculum development. Further, Maurer (1986:88) showed this technique to be effective in the California community college environment.

For the present study, two full-time members of the mathematics department acted as the monitor team and thirteen of the fourteen full-time mathematics instructors (including the two instructors on the monitor team) agreed to participate as the respondent group.

Based on the description of the basic mathematics programs used by California community colleges determined from an earlier component of this study, the monitor team constructed the first round Delphi questionnaire dealing with recommendations for the elements of such a program at Saddleback College. The questionnaire response scales and lack of a neutral option were chosen to conform to the recommendations of Turoff (1975:90-91). The request of the respondents to list, in order, the three most important items in a category was the method used by Maurer (1986:51) to identify components not foreseen by the authors of the questionnaire. An example of this questionnaire was placed in Appendix C. Two members of the respondent group, other than those also acting as the monitor team, were given the questionnaire and asked to complete it as the pilot stage in the development of the questionnaire. They found the questionnaire satisfactory as written. This questionnaire was personally delivered to each remaining member of the respondent group by a member of the monitor team along with a written summary of the results of two previously completed components of the study: (1) a description of the basic mathematics programs used by California community colleges and (2) a summary of the demographic differences between the students in basic mathematics courses and those in the algebra courses at Saddleback College. It was requested that the questionnaires be returned to a member of the monitor group within a period of one week. All members of the respondent group complied with this request.

The monitor team collected the completed questionnaires and computed the mean response for each item using the following four-point scale: four points for VI (very important) or SA (strongly agree), three points for I (important) or A (agree), two points for SI (slightly important) or D (disagree), one point for UI (unimportant) or SD (strongly disagree). Responses of NJ (no judgment) were not given a numerical value nor were they used in the calculations of the mean. Once calculated, the mean score was reinterpreted as a value statement using the following interval scale: UI,SD [1.0,1.25); UI+,SD- [1.25,1.50); SI-,D+ [1.50,1.75); SI,D [1.75,2.25); SI+,D- [2,25.2.5); I-,A- [2.5,2.75); I,A [2.75,3.25); I+,A+ [3.25,3.5); VI-,SA- [3.5,3.75); VI,SA [3.75,4.0]. The symbols "+" and "-" were used in the traditional educational fashion to mean a little more than the base value and a little less than the base value, respectively.

The round two questionnaire was created by adding those items recommended by the respondent group from round one and noting the mean responses from the first round. Each member of the respondent group was given a copy of the questionnaire on which were indicated their individual responses from the first round (Appendix D). The respondent group was asked to reevaluate their previous judgments in light of the group response, to respond to the new items, and to return the completed questionnaire to a member of the monitor group within one week. All members of the respondent group complied with this request.

The monitor team collected the completed round two questionnaires and computed the mean response for each item using the same scales employed for round one. The numerical mean was reinterpreted as a value statement using the same interval scale employed in round one. This information was given to each member of the respondent group (Appendix E).

Based on the responses to the questionnaire of round two, the review of related literature, and the survey of the California community colleges, the monitor team constructed a questionnaire with specific basic mathematics program curriculum components. This round three questionnaire was distributed to the respondent group. It was requested that the questionnaires be returned to a member of the monitor group within a period of one week. All members of the respondent group complied with this request (Appendix F). The monitor team collected the completed round three questionnaires and tabulated the responses. These responses were incorporated into the round four questionnaire.

The monitor team constructed the round four questionnaire by adding to the round three questionnaire items recommended by the respondent group, the tabulations from round three, and an indication of their individual responses. The respondent group was given the opportunity to change their selections from round three and to judge the new items. It was requested that the questionnaires be returned to a member of the monitor group within a period of one and one-half weeks. All members of the respondent group complied with this request (Appendix G).

The monitor team collected the completed round four questionnaires and tabulated the responses. Those items receiving more affirmative than negative responses were used to form the faculty recommendations from the Delphi exercise. In those cases where mutually exclusive items received more affirmative than negative votes, the item with the most affirmative selections was adopted.

The faculty collected heavily on one side of an issue or the other in all but a few cases For example, all thirteen instructors indicated support for the pre-algebra course, eleven felt it should not be repeatable twice, all nine who expressed a judgment felt that three units was the appropriate credit value. In a few areas, the simple count of affirmative and negative responses resulted in an equal or nearly equal number on opposing sides of an issue. To insure the correct interpretation in these cases, questionnaires were again read and the overall opinion of the respondent in these areas judged. The decision was made to choose as the departmental position the view with the most individuals in support. Those questionnaire items for which such an analysis was necessary were followed by a summary of the analysis in the display of the round four results in Appendix H.

This set of faculty recommendations was evaluated in terms of practicality, completeness, and consistency. This evaluation was based on the knowledge gained from the literature review and learning environments survey. Although the monitor team had the right, inherent with a Delphi exercise, to make additional recommendations for the basic mathematics program at Saddleback College, such action did not appear necessary and was therefore not exercised. This set of faculty recommendations was the answer to research question 3: "What course content, organization, and learning environments were most appropriate for the Saddleback College basic mathematics program?"

Program Cost Analysis

Because the added cost or reduction in cost to Saddleback College of any program revision was an important factor effecting the likelihood of adoption, an estimate of this financial impact was made. It was decided to base the income analysis on the student enrollment figures for the 1988 spring term since these were already an integral part of the study. It was on these figures that the student demographic analysis was based. The actual number of class sections of basic mathematics offered in that semester was not used in the analysis, because the large lecture class format was not available following the adoption of developmental status for the basic mathematics course in the 1988 fall term. It was assumed that twelve sections that averaged thirty-five students each were used to serve the 424 students enrolled in the 1988 spring term. A student enrollment model was constructed based on the expectations for the recommended program. Included in this model were assumptions that specified student interest in self-paced sections and the tutorial laboratory. Further, assumptions were made concerning student attrition from the recommended program.

Since it was felt that program implementation would not require the purchase of any additional equipment or materials, salaries were the sole form of expenditure considered. Instructor salaries were based on the figure used by the college in general budget considerations -- fifty-thousand dollars each year for one full-time instructor. The number of full-time equivalent instructors required by a program was found for lecture classes by dividing the product of the number of course sections and the number of hours the course met each week by thirty. In laboratory classes the expenditure was one-half of that figure. The cost of peer tutors was set at the wage rate used in the 1988 fall term. This value was $4.25 each hour.

To cover operating expenses the college received funding from the state based on the number of students enrolled at the college. The basic unit of revenue was one average daily attendance or ADA. Grossly, an ADA was equivalent to the load carried by a single student who enrolled in fifteen units for both semesters in a year. More precisely, the number of ADA produced by a program was determined from the following expression:

$$0.5 * (C1 + C2) * H * 16.6 * 0.911 + 525$$

where $C1$ was the number of students enrolled at the first census

$C2$ was the number of students enrolled at the second census

H was the number of hours the class met each week.

The state paid three thousand dollars for each ADA credited to the college.

The basic mathematics program income was found by subtracting the expenditures from the revenues. It was on this income figure that the financial impact of the existent and recommended program were compared. This comparison provided an answer to research question 4: "What cost would be associated with the implementation and maintenance of this recommended program and how did the cost compare with the current level of funding for the basic mathematics program area?" A complete description of the program model, revenue, and expenditure calculations were placed in Appendix I.

Chapter 4

PRESENTATION OF RESULTS

Review of the Basic Mathematics Programs in the California Community Colleges

The review of the basic mathematics programs of the 105 degree granting California community colleges revealed that 102 colleges offered an arithmetic course or courses in the mathematics department. The basic mathematics courses were offered by two colleges in a separate skill development or developmental education department that also housed the remedial reading and writing programs. In one case this activity was organized as a separate division that reported directly to the dean of instruction. In another college, the basic skills department was under the jurisdiction of the dean of the humanities division. In the former case the organizational structure was less than two years old, while the later college had had the organization described for at least fifteen years. The third college with a basic mathematics program not part of the mathematics department offered the arithmetic courses through the independent applied computational skills department. This department was managed by the director of the college tutorial activity who was responsible directly to the academic dean of instruction. Remedial reading and writing were not part of this organization.

These results may be contrasted with Kipps' (1966:155) finding, following a similar survey of the seventy-three California public junior colleges in 1965, that all but eleven colleges offered an arithmetic course or courses in the mathematics department. Of the eleven colleges, two were newly opened and did not yet have an arithmetic course. The remaining nine offered an arithmetic course in a department other than mathematics. Of the nine colleges, only Sierra College, as of the 1988 survey, still did not offer arithmetic in the mathematics department. However, arithmetic was present in the skill development department separate from the forestry location identified by Kipps. Sierra College and San Jose City College represented the sole examples in the California community colleges of the recommendation by Roueche and Snow (1977) for a separate administrative entity for the developmental programs of reading, writing, and mathematics. The California community colleges had almost totally conformed to the model recommended by Hecht and Akst (1980:253) and others that called for the basic mathematics program to be under the jurisdiction of the mathematics department.

The courses in the basic mathematics program fell into three basic categories: (1) Arithmetic Fundamentals: addition, subtraction, multiplication, and division using whole numbers, fractions, and (usually) decimals; (2) Arithmetic: included the contents of the arithmetic fundamentals course noted above along with the topics of percent, applications, measurement, and (often) applied geometry; (3) Arithmetic/Introduction to Algebra: included the contents of the arithmetic course noted above, along with an introduction to algebra including the solution techniques for simple linear equations. These courses in the basic mathematics program were not always represented in the curriculum by single distinct classes. Occasionally a sequence of courses or course modules were used to complete the material in the categories noted above. These course or module sequences were often organized around the philosophy of mastery learning. The student earned units as competency in modules or parts of the entire course curriculum were satisfactorily demonstrated. When all modules had been completed, full course credit was awarded. Classes were offered in lecture formats, laboratory formats, and combinations of the two as described below. These classes were available in traditional instructor- or class-paced, self-paced, or individualized forms. Independent study courses were available at fifteen schools.

The arithmetic fundamentals course was offered at twelve colleges, sixty-eight colleges offered the arithmetic course, and fifty colleges offered the arithmetic/introduction to algebra course. The arithmetic fundamentals and the arithmetic courses were both offered at four colleges. The arithmetic fundamentals and arithmetic/introduction to algebra courses were both given at five colleges. The arithmetic and arithmetic/introduction to algebra courses were both offered at sixteen colleges. No college provided all three courses. The distribution of basic mathematics courses among the California community colleges was placed in the Venn diagram of Figure 1.

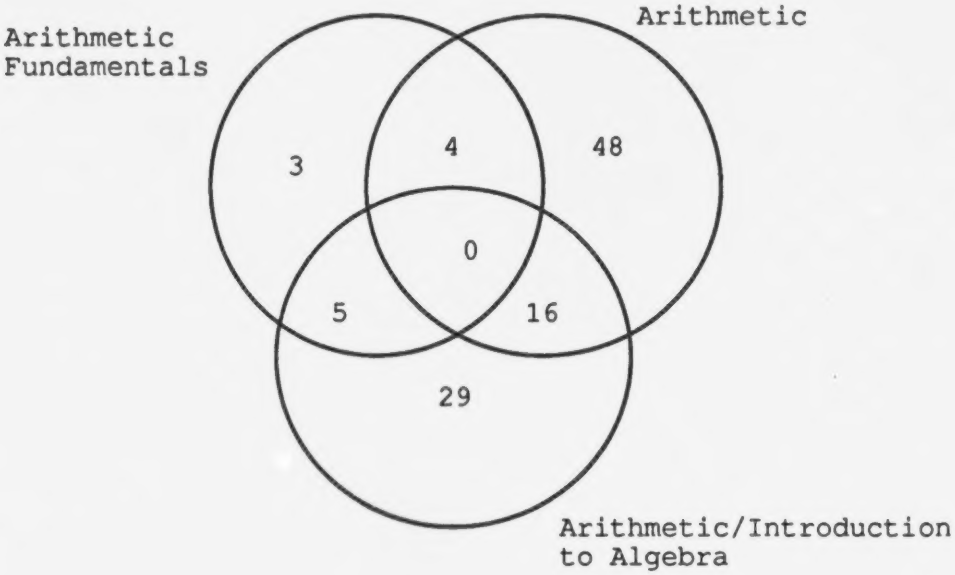

Figure 1

Distribution of the Basic Mathematics Course
Among the California Community Colleges

The arithmetic fundamentals course was offered at twelve colleges. Modular versions of this course were found in four of these colleges. The most often used format for non-modular courses was the three hours lecture each week for three semester units. None of the five California community colleges on the quarter system offered this class. The number of units awarded for student competency of this material ranged from two to six. At seven colleges the course was scheduled strictly lecture, one college scheduled it as strictly laboratory, and four colleges offered it as a lecture/laboratory combination class. The scheduling formats used by the twelve colleges providing this class were placed in Table 1 and Table 2.

Table 1

Arithmetic Fundamentals Scheduling Format for Non-Modular Courses

Number of Colleges	Lecture Hours	Lect/Lab Hours	Lab Hours	Units
5	3	0	0	3
1	3	0	0	2
1	0	3	0	3
1	1	0	3	2

Table 2

Arithmetic Fundamentals Scheduling Format for Modular Courses

Number of Colleges	Lecture Hours	Lect/Lab Hours	Lab Hours	Maximum Units
1	3 per 3 units	0	0	6
1	3	0	0	3
1	0	0	2 per 1 unit	4
1	0	2 per 1 unit	0	6

The arithmetic course was offered at sixty-eight colleges. Non-modular versions of this class were present at fifty-one colleges, twenty-three colleges had modular versions, and six colleges offered both. In thirty-nine colleges the class was classified strictly lecture, twenty-eight colleges used both lecture and laboratory formats, while one college allowed only a strictly laboratory format. The most often used format for non-modular courses was the three hours lecture each week for three semester units. This was used by thirty-one colleges. The only college on the quarter system that offered a non-modular version of the arithmetic class used four hours lecture per week and gave four quarter units. The most often used format for modular courses was also the three hours lecture per week for three semester units and four colleges used this form. Each of the three colleges on the quarter system that offered non-modular versions of this class held the class for five lecture hours per week and gave a maximum of five quarter units. At nineteen colleges the class was available in more than one scheduling format. The scheduling formats used by the sixty-eight colleges having this class were placed in Table 3 and Table 4.

The results in Tables 3 and 4 may be contrasted with the findings of Kipps (1966:72) in the 1965 survey of the California public community colleges. She found that students in fifty-eight percent of the sixty-seven arithmetic classes taught through mathematics departments during the day

Table 3

Arithmetic Scheduling Format
Non-Modular Courses

Number of Colleges	Lecture Hours	Lect/Lab Hours	Lab Hours	Units
31	3	0	0	3
4	2	0	0	2
4	3	0	0	2
2	4	0	0	4
1	5	0	0	3
1	5 for 9 weeks	0	0	1
1	4	0	0	1
1	4	0	0	2
1	4	0	1	2
1	4	0	0	3
1*	4 for a quarter	0	0	4Q
1	3	0	1	3
1	3	0	3	4
1	2	0	0	1
1	2	0	3	2
1	2	0	3	3
1	1	0	0	1
1	0	0	8	3

* This college also offered an optional 3 hours CAI laboratory for an additional quarter unit.
Q: Quarter units

Table 4

Arithmetic Scheduling Format
Modular Courses

Number of Colleges	Lecture Hours	Lect/Lab Hours	Lab Hours	Maximum Units
4	3	0	0	3
3	5 for a quarter	0	0	5Q
3	3	0	2	3
2	0	0	3 per unit	3
2	1 per unit	0	0	3
2	2	0	3	3
1	4	0	0	3
1	4	0	0	4
1	3	0	2	3.5
1	3	0	1 per 3 units	9
1	2	0	3 for 6 weeks	1
1	2	0	1	2
1	1	0	2	2
1	1	0	3	2
1	1	0	3	3
1	1 per 0.5 unit	0	0	3.5
1	1	0	2	8
1	0.5	0	1.5 per unit	4
1	0	0	3	1
1	0	3	0	2
1	0	0	3	3

received three units, students in twenty-eight percent received two units, students in ten percent received between one-half and one and one-half units while students in three percent of these classes received no credit at all. It was clear that in 1988 every college gave credit for the arithmetic course.

The arithmetic/introduction to algebra course was offered at fifty colleges. Non-modular versions of this class were given at forty-two colleges, fourteen colleges offered modular versions, and six colleges offered both. In thirty-nine colleges the only format available was lecture, while eleven offered a laboratory component. In no college was a strictly laboratory course the only option available to students. The most often used format for non-modular courses was three hours lecture per week for three semester units. This was used by thirty-one colleges. The only college on the quarter system offering a non-modular version of the arithmetic/introduction to algebra class used three hours lecture per week and gave two quarter units. The only modular format adopted by more than one college called for one lecture hour per unit and allowed a maximum of four units. This format was used by two schools. At nine colleges more than one scheduling format was available to students. The scheduling formats used by the fifty colleges that offered the arithmetic/introduction to algebra class were placed in Table 5 and Table 6.

In addition to these basic mathematics courses, twelve colleges had a course in their curriculum designed to provide tutoring assistance for students enrolled in pre-algebra mathematics courses. The most common scheduling formats were the two hours per week for one unit and the

Table 5

Arithmetic/Introduction to Algebra Scheduling Format for Non-Modular Courses

Number of Colleges	Lecture Hours	Lect/Lab Hours	Lab Hours	Units
31	3	0	0	3
3	5	0	0	5
2	3	0	0	2
2	5	0	0	4
2	5	0	0	3
2	2	0	2	3
1	4	0	0	4
1	4 for 9 weeks	0	0	2
1	3	0	2	3
1	2	0	0	2
1	2	0	3	2
1	1.5	0	1.5	2
1	1	0	3	2
1	0	3 for a quarter	0	2Q

Q: Quarter units

Table 6

Arithmetic/Introduction to Algebra Scheduling Format for Modular Courses

Number of Colleges	Lecture Hours	Lect/Lab Hours	Lab Hours	Maximum Units
2	1 per unit	0	0	4
1	1 per unit for a quarter	0	0	4Q
1	1 to 2	0	0	3
1	3	0	2	2
1	5 for a quarter	0	0	5Q
1	5 per unit	0	0	3
1	4	0	0	4
1	3	0	0	4
1	0	6	0	3
1	0	0	3 per unit	3
1	3	0	1	3
	and			
	3 for 9 weeks	0	0	1
1	3	0	0	2
	and either of the following:			
	2 for 9 weeks	0	0	1
	or			
	1 for 9 weeks	0	2	1

Q: Quarter units

three hours per week for one unit. Each of these was adopted by three of the twelve colleges that offered such a course. The complete list of available formats was placed in Table 7.

Table 7

Tutoring Classes Schedule Format

Number of Colleges	Hours	Units
3	2 per week	1
3	3 per week	1
1	2 per week	0
1	3 per week for 9 weeks	0.5
1	24 per semester	0.5
1	27 per semester	0.5
1	1.5 to 9 per week	0.5 to 1.5
1	open lab	0

Survey of the Basic Mathematics Learning Environments Available in the California Community Colleges

The survey of the mathematics faculty in the 105 degree granting California community colleges provided a detailed view of many of the practices used in the instruction of basic mathematics throughout the state. Mathematics faculty members were asked to describe those practices available to students at the basic mathematics level. Faculty at the twenty-five colleges offering more than one category of basic mathematics class were not asked to differentiate practices between specific courses.

Live lecture was an instructional mode available to basic mathematics students at ninety-one colleges. This was the only lecture delivery system available at seventy-five colleges, while twenty-two had lectures available on video or audio tapes or both, thirty colleges gave the student an option of taking a class where no lecture was given, and eight colleges gave no option of lecture, live or taped, to their students. The distribution of the types of lecture delivery was placed in Figure 2.

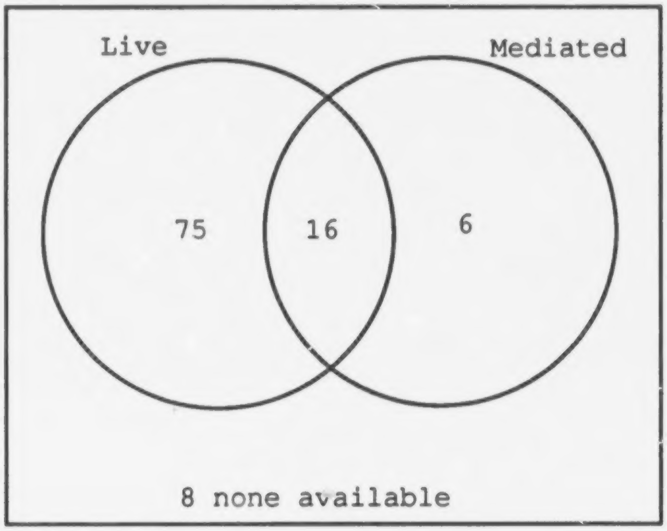

Figure 2

Distribution of Lecture Availability
Among the Colleges

Students in basic mathematics courses at all colleges were supported with written materials. Standard commercial textbooks were used at seventy-one colleges, forty-two had workbooks and twenty, programmed texts. The distribution of these materials through the California community colleges was shown in Figure 3.

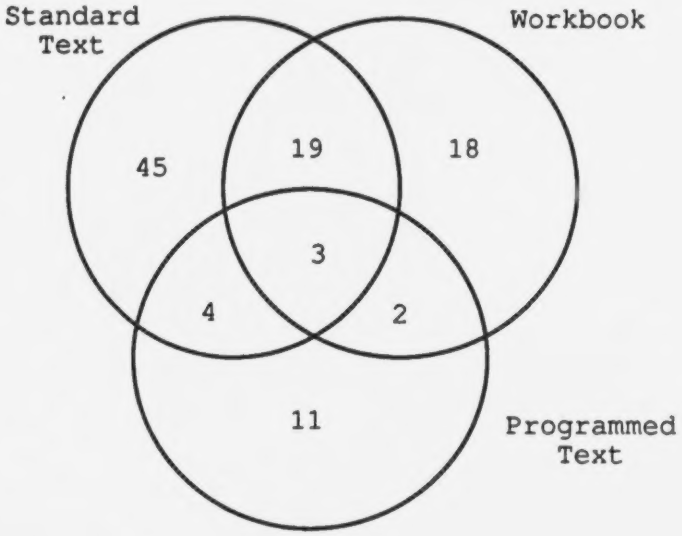

Figure 3

Distribution of the Textbooks Among the California Community Colleges

While thirty-nine colleges supplemented the courses with instructor handouts, in only three colleges was this the only written material given to basic mathematics students. Both handouts and a standard text were available at twenty-one colleges, sixteen colleges used handouts and a workbook, and ten colleges, handouts and a programmed text. The distribution of instructor handouts among the various types of books used was placed in Figure 4.

Computer-aided instruction was used by forty-three colleges. Stand alone microcomputers were the sole type of machine in use at thirty-four colleges, seven colleges had only mainframe computer systems or microcomputers tied to a central disk, and two colleges had both stand alone and central disk or mainframe capability.

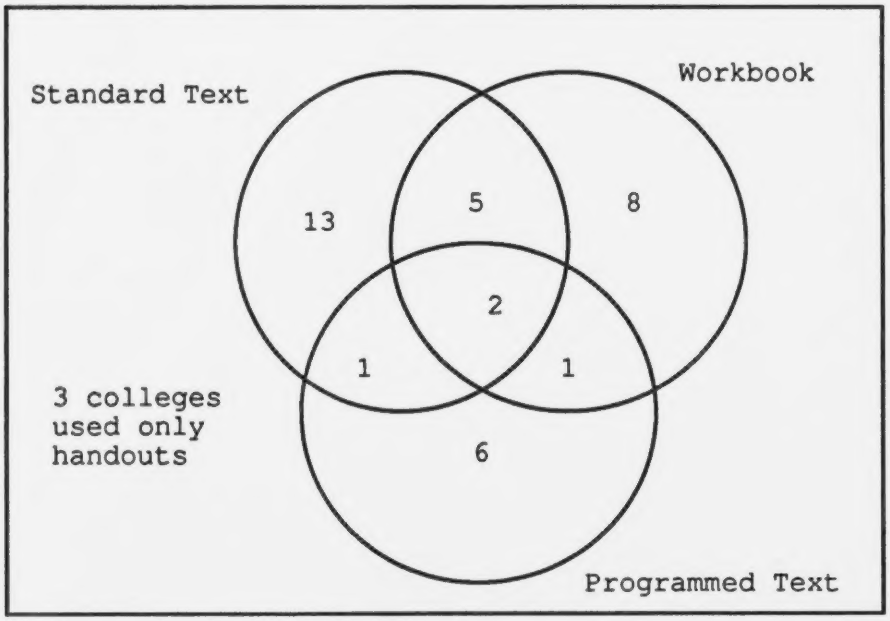

Figure 4

Distribution of Instructor Handouts
Over the Types of Books Used for
Basic Mathematics Courses

In all, fifty-two colleges used some form of mediated instructional support for the basic mathematics program. Besides the forty-three colleges with CAI available, fourteen had audio tapes, sixteen used video tapes, and five had all three. The distribution of the mediated instruction techniques was placed in Figure 5.

The primary instructional location for basic mathematics was the classroom. This option was available to students at ninety-nine colleges and was the only option in forty-seven. The services of a mathematics learning center were used at thirty-seven colleges for the basic mathematics course, while twenty-nine colleges involved a college learning center in this mathematics program. In Figure 6

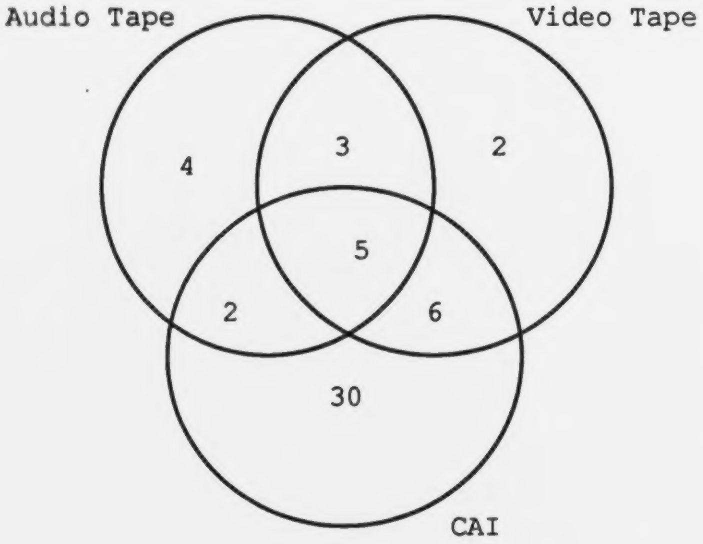

Figure 5

Distribution of Media Used for Basic Mathematics Among the Colleges

was placed the distribution of instructional locations used by the colleges.

The traditional, instructor-paced and -directed course format was used most often for basic mathematics classes. This format was offered at ninety-five colleges. In sixty-one colleges this was the only format available. A self-paced option occurred at forty-four colleges. Students had no other option than a self-paced instructional format at ten colleges. Open-entry/open-exit was available in thirty-one colleges. Of the forty-one colleges that subscribed to the mastery learning format, seven executed it in the context of a traditional, instructor-paced format. Independent study was allowed in fifteen colleges. Twenty-nine colleges gave variable credit depending on the amount of work completed and

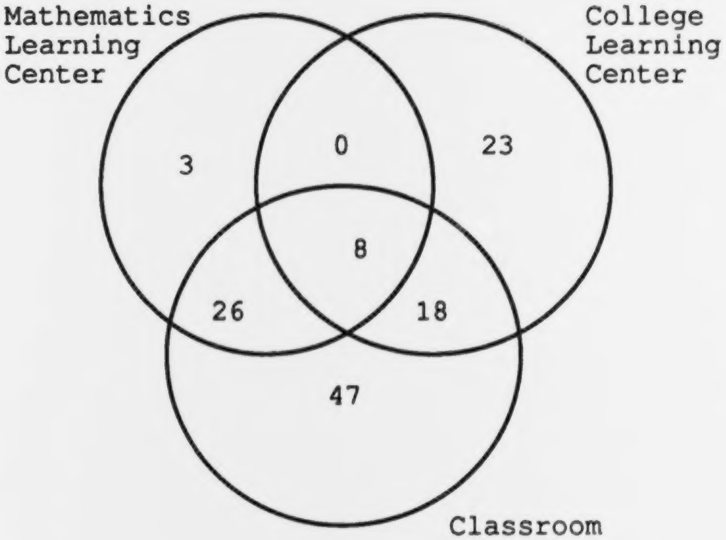

Figure 6

Distribution of Instructional Location
Among the Colleges

eleven allowed the students to extend work into the next term by using the "in progress" grade.

In thirty-two colleges, group workshops were held to aid students enrolled in basic mathematics courses. Faculty led workshops in twenty colleges, paraprofessionals led them in eleven colleges, and students were the leaders in fourteen colleges.

Tutoring was a common support service provided to basic mathematics students in California community colleges. It was present in some form in every college except Vista College, which is a non-campus college operated by the Peralta Community College District. Peer or student tutoring was provided at ninety-six colleges, but in only fifty-one colleges was this the sole source of tutoring available.

Paraprofessional tutors were employed at thirty-five colleges. In twenty-nine colleges, faculty tutored in addition to their regular office hour assignment. The distribution of the use of faculty, students, and paraprofessionals for tutoring in the California community colleges was placed in Figure 7.

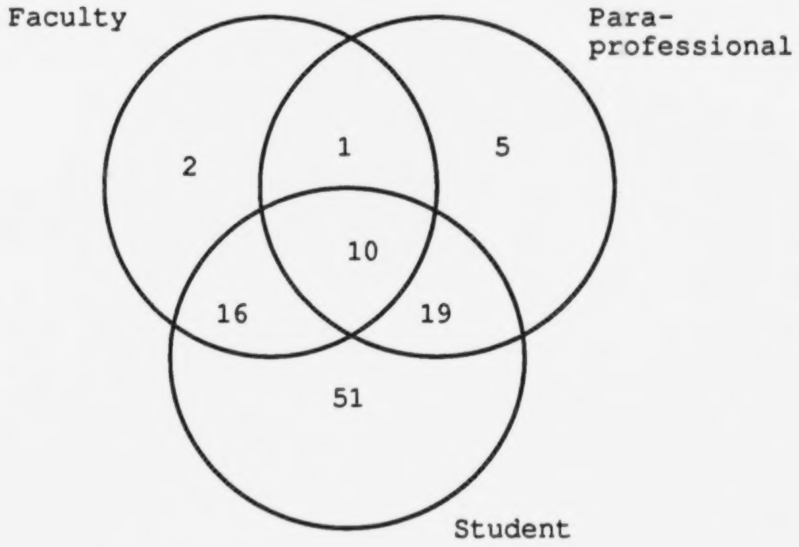

Figure 7

Distribution of Tutoring Personnel
Among the Colleges

A learning center was the most frequently noted location for tutoring. A mathematics learning center was used by fifty-three colleges, a college learning center also by fifty-three, and eighty-nine colleges reported using one or both such facilities. In twenty colleges tutoring took place in a classroom. Facilities other than a classroom or learning center were used for tutoring at fifteen colleges. The distribution of the tutoring locations among the colleges was shown in Figure 8.

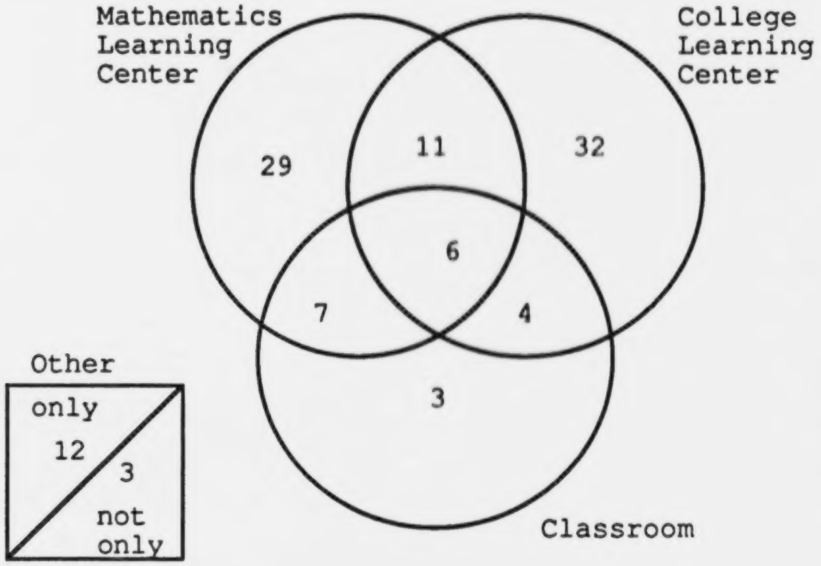
Mathematics Learning Center
College Learning Center
29
11
32
6
7
4
3
Classroom
Other
only
12
3
not only

Figure 8

Distribution of Tutoring Location
Among the Colleges

A learning center provided support for students in nearly all California community colleges. A mathematics learning center was in existence in fifty-six colleges, seventy had a general college learning center, and ninety-nine colleges had one or the other or both. In sixty-seven colleges the learning center or laboratory was open for students to drop in when they wished to study or were in need of help. Laboratory time was a regularly scheduled activity for the basic mathematics students in thirty-nine colleges and a required part of the course in thirty colleges. As described in chapter three, all California community colleges received funding from the state based on the level of student enrollment. At thirty-eight colleges student activity in the learning center contributed to the student enrollment figures, and thus generated additional support monies for the college. The most often noted function of the learning center was tutoring. This was a function of the learning center at eighty-four colleges. At forty-six colleges the learning center offered a CAI capability and twenty-two allowed some form of mediated instruction. Testing was also an important feature of the learning center. Diagnostic testing was carried out in the learning center of thirty-two colleges. The center in thirty-four colleges conducted regular course testing.

Comparison of Basic Mathematics and Algebra Student Demographics

The demographics of the group of students enrolled in basic mathematics at Saddleback College was compared with the group of students enrolled in beginning or intermediate algebra through the used of two independent random samples of one hundred students from each population.

Hypothesis 1 -- Mean Age

The mean age of arithmetic students was calculated to be 27.0 years while the mean age of algebra students was 22.5. The statistical significance of this difference in average age was tested using a two-tailed large sample z-test for the difference between two population means at the 0.05 level of significance. The calculated z value was 3.83 and far exceeded 1.96, the critical value of z. The probability that the two populations had the same mean age and that the observed age difference occurred by chance was less than 0.05. Consequently, the null hypothesis was rejected and the alternate hypothesis was accepted.

Hypothesis 2 -- Mean Number of Units Completed

The mean number of units completed by basic mathematics students with more than zero units completed was calculated to be 25.09. The mean number of units completed by algebra students with more than zero units completed was found to be 24.82. The statistical significance of this difference in mean units completed was tested using a two-tailed large sample z-test for the difference between two population means at the 0.05 level of significance. The critical values of z were found to be z = 1.96 and -1.96. The computed z value of 0.0806 did not fall within the critical region. There was a probability of greater than 0.95 that the observed difference was due simply to chance and consequently the null hypothesis was not rejected.

Hypothesis 3 -- Mean Grade Point Average

The mean grade point average of basic mathematics students was found to be 2.53. The mean grade point average of algebra students was calculated to be 2.65. The statistical significance of this difference in grade point average was tested using a two-tailed large sample z-test for the difference between two population means at the 0.05 level of significance. The critical values of z were found to be z = 1.96 and -1.96. The computed z value of 0.68 did not fall within the critical region. There was a probability of greater than 0.95 that the observed difference was due simply to chance and consequently the null hypothesis was not rejected.

Hypothesis 4 -- Proportion of Students With No Units Completed

The proportion of basic mathematics students with no units completed at Saddleback College was found to be 0.25. The proportion of algebra students with no units completed at Saddleback College was found to be 0.07. The statistical significance of this difference in proportion of students with no units completed at Saddleback College was tested using a two-tailed large sample z-test for the difference between two population proportions at the 0.05 level of significance. The calculated z value was 3.39 and far exceeded 1.96, the critical value of z. The probability that the two populations had the same proportion of members with no units completed at Saddleback College and that the observed difference occurred by chance was less than 0.05. Consequently the null hypothesis was rejected and the alternate hypothesis was accepted.

Hypothesis 5 -- Sex Distribution

The proportion of arithmetic students who were female was found to be 0.67. The proportion of algebra students who were female was found to be 0.50. The statistical significance of this difference in sex distribution between the arithmetic and algebra students was tested using a two-tailed large sample z-test for the difference between two population proportions at the 0.05 level of significance. The calculated z value was 2.44 and exceeded 1.96, the critical value of z. The probability that the two populations had the same sex distribution and that the observed difference occurred by chance was less than 0.05. Consequently the null hypothesis was rejected and the alternate hypothesis was accepted.

Hypothesis 6 -- Proportion of White, Not Hispanic Students

The ethnic distribution of the students in the two independent samples was displayed in Table 8. Those who responded "other" were grouped with the identified white, not Hispanic students to create the effective white, not Hispanic group. It was found that the proportion of basic mathematics students who were classified as white, not Hispanic was 0.84 and the proportion of the algebra student group who were classified as white, not Hispanic was 0.86. The statistical significance of this difference in the ethnic distribution between the basic mathematics students and algebra students

Table 8

Ethnic Distribution of Student Samples

Ethnicity	No. in Basic Math	No. in Algebra
White, not Hispanic	79	84
Black, not Hispanic	5	1
Hispanic	6	5
American Indian or Alaskan Native	2	0
Filipino	1	0
Asian or Pacific Islander	0	6
Other	2	2
No Answer	5	2

was tested using a two-tailed large sample z-test for the difference between two population proportions at the 0.05 level of significance. The critical values of z were found to be z = 1.96 and -1.96. The computed z value of -0.40 did not fall within the critical region. There was a probability of greater than 0.95 that the observed difference was due simply to chance and consequently the null hypothesis was not rejected.

Hypothesis 7 -- Ethnic Distribution

The ethnic distribution of the basic mathematics and algebra student samples was shown in Table 8. The statistical significance of the difference in distribution between the basic mathematics and algebra student populations was examined using the chi-square test for the difference between several population proportions at the 0.05 level of significance. The critical chi-square value, with seven degrees of freedom, was 14.07 and exceeded the calculated chi-square value of 13.20. Consequently the null hypothesis was not rejected. However, because the calculated value was so close to the rejection region final judgment was reserved on this hypothesis.

Recommendations for Improving the Basic Mathematics Program at Saddleback College

Program Objectives, Organization, and Support Services -- Delphi Rounds One and Two

The first two rounds of the Saddleback College mathematics faculty Delphi exercise were focused on defining the appropriate program objectives, organization, and support services for the basic mathematics program at Saddleback College. Those items rated very important (VI), strongly agree (SA), unimportant (UI), or strongly disagree (SD) were placed in Table 9 in rank order. The maximum value for the mean was 4.0 and the minimum value was 1.0. The rank order of all elements was placed in Appendix E.

It was clear from these responses that readying the otherwise unprepared student for the beginning algebra course was the most important objective of the basic mathematics

Table 9

Delphi Round Two Rank Order Responses

Element	value	mean	rank
Objectives:			
B. Prepare the student for success in algebra.	VI	3.77	1
A. Help the student develop good study habits.	VI-	3.62	2
K. Develop "number sense"--the ability to judge whether an answer is reasonable or ridiculous.	VI-	3.62	3
. . . .			
E. Screen out those students who will not be successful in college level work and dissuade their continuance.	UI	1.23	15
Organization:			
U. Courses in this program should be taught by caring and interested instructors.	SA	3.85	1
C. The arithmetic/pre-algebra program should be offered through the mathematics department.	SA	3.77	2
E. A student enrolled in this program should have a variety of instructional styles from which to choose.	SA-	3.69	3
K. The instructional materials should include the arithmetic of signed numbers.	SA-	3.54	4
. . . .			

Table 9 (Cont.)

Element	value	mean	rank
J. The instructional materials should not include any topic presented in beginning algebra.	SD-	1.33	24
B. The arithmetic/pre-algebra program should be offered by the College through a special developmental skills department separate from the mathematics department.	SD-	1.31	25
A. No arithmetic/pre-algebra program should exist at Saddleback College	SD	1.23	26
Support Services:			
M. Student assessment/diagnostic testing.	VI	3.92	1
P. Student advisement/counseling.	VI	3.85	2
R. Diagnostic testing with results available to the student and instructor during the first week of class.	VI	3.77	3
V. A math lab that is open as many hours as possible.	VI	3.75	4
D. Live lectures.	VI-	3.62	5
B. Drop-in tutoring outside class.	VI-	3.62	5
L. Convenient student group study areas outside the classroom.	VI-	3.62	5
T. Availability of both peer and faculty tutoring.	VI-	3.54	8
I. A mastery learning environment.	VI-	3.50	9

program. To accomplish this objective, the mathematics department felt strongly that the program should be offered by caring, interested instructors and under its jurisdiction. Further, the availability of a variety of instructional styles from which the student could choose was strongly recommended. It was agreed that these techniques would included both instructor-paced and student self-paced approaches. It was further agreed that the program material should include the arithmetic of whole numbers through the solution techniques for simple linear equations, but not extend further into the algebra topics involving polynomial operations.

The mean faculty responses were contradictory in the single area of how many courses should constitute the basic mathematics program at Saddleback College. The mean faculty response implied agreement with both the following items listed under the organization category:

N. The program should include an arithmetic course as well as a pre-algebra course.

D. The program should consist of a single one semester course.

To resolve this contradiction, the individual questionnaires were reviewed with attention paid to the individual consistency of responses over these two items. It was found that one respondent supported neither option, three respondents supported both positions, four preferred a single course, and five wanted two courses. Removing from consideration those whose positions were contradictory, it was decided that the heaviest weight of opinion among the mathematics department faculty was in support of two courses in the basic mathematics program.

Although it was apparent that there was support for two courses in the basic mathematics program it was not clear whether a sequential model or parallel course model was preferred. A sequential model would involve an arithmetic fundamentals course for the particularly weak students. This course would then be followed by an arithmetic/introduction to algebra course that devoted little time to a review of the arithmetic of whole numbers and decimals. A parallel model would involve two arithmetic/introduction to algebra courses, but one would move at a slower pace to allow the weaker students to develop sufficient skills in each topic area. The other course would move more rapidly and would serve students needing only a review or possessing strong arithmetic computational skills. Because of this uncertainty, all these three course were placed in the candidate program for faculty consideration with the third round Delphi exercise. Included, also, were the options of a variety of instructional styles and an open-entry/open-exit format that the faculty had found to be important.

The primary support services desired by faculty for students in the basic mathematics program revolved around assessment testing/counseling and a mathematics learning center. Under state mandate, the college was developing an assessment testing and advisement capability. A model for mathematics learning center usage by basic mathematics students was incorporated into the candidate program.

Faculty Program Recommendations -- Delphi Rounds Three and Four

Consistent with the earlier result that the faculty felt a mathematics learning center provided a very important support service for basic mathematics students, twelve of the thirteen faculty members supported the creation of a laboratory course for these students. This course would offer students a tutorial service and access to computer-aided drill, and practice activities. For identification in the study, it was titled Mathematics Tutorial. The student would be scheduled into the laboratory for two hours each week and receive one-half unit. The tutorial course would be repeatable eight times. This high maximum number of repeats would remove student fear that they would be prevented from enrolling if several semesters were needed to complete the basic mathematics program.

All thirteen mathematics faculty members felt the basic mathematics program should include at least one lecture course. One faculty member felt there should be a single lecture course of the variety previously described as arithmetic/introduction to algebra. This course would only briefly touch on the arithmetic of whole numbers and decimals and would be identified at Saddleback College as Pre-Algebra Mathematics. Of the twelve remaining faculty members, seven expressed support for two basic mathematics courses, four supported three courses, and one wanted two courses but did not make a judgment on having a third course. There was disagreement among those seven instructors recommending two courses as to which second course would best supplement the pre-algebra mathematics course upon which they mutually agreed. An arithmetic fundamentals course was sought by two instructors while six thought an arithmetic/introduction to algebra course, identified at Saddleback College as Basic Mathematics, that proceeded at a slower pace than the pre-algebra mathematics course and dealt with the arithmetic of whole numbers and decimals in some detail was most appropriate. Those who supported three course saw value in offering pre-algebra, basic mathematics, and the arithmetic fundamentals course. A Venn diagram of the distribution of the faculty support among the three courses was placed in Figure 9.

Based on the distribution displayed in Figure 9, it was determined that the majority of faculty supported two courses in the program and the preferred second course was basic mathematics. The format of these two courses, based on those questionnaire items that received more affirmative than negative votes was described below.

The Pre-Algebra Mathematics course would carry a unit value of three, meet for three hours each week, and be repeatable once. A satisfactory score on the mathematics assessment examination would be required for admission to the course. It would be offered both in an instructor-paced, lecture format and a student self-paced format. The self-paced version would take place in a classroom setting and not

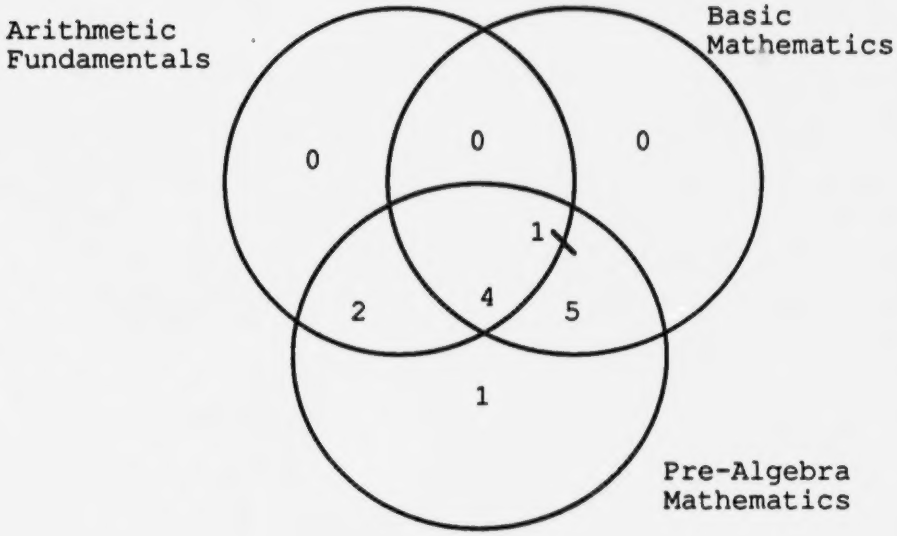

Figure 9

Distribution of the Basic Mathematics Courses Supported by the Saddleback College Mathematics Faculty

be an independent study situation. The self-paced version would involve mediated instruction and be organized around a mastery learning philosophy. The class would be open-entry/open-exit and consequently students could enter at any time during the semester and exit immediately after completing the course requirements. In conjunction with both the instructor-paced, lecture and student self-paced versions the student would have the opportunity to enroll in the one-half unit mathematics tutorial laboratory course.

The subject content of the Pre-Algebra Mathematics course would be the following: a brief review of the arithmetic of whole numbers and decimals, the arithmetic of fractions and signed numbers, the order of operations, ratios and proportions, percent, scientific notation, calculations involving whole number powers and roots. The content would include consideration of the following geometrical concepts: perimeter, area, volume, the metric system and measurement with an emphasis on the proper use of units. Algebra would be introduced through the inclusion of the solution techniques for simple linear equations and the manipulation of common formulas. Problem solving techniques would be developed through the inclusion of material related to the translation of word phrases to mathematical expressions, word problems, the use of calculators and estimation of results.

The Basic Mathematics course would carry a unit value of four, meet for four hours each week, and be repeatable twice. It would have no prerequisite. It would be offered both in an instructor-paced, lecture format and a student self-paced format. The self-paced version would take place in a classroom setting and not be an independent study situation. The self-paced version would involve mediated instruction and be organized around a mastery learning philosophy. The class would be open-entry/open-exit and consequently students could enter at any time during the semester and exit immediately after completing the course requirements. In conjunction with both the instructor-paced, lecture and student self-paced versions the student would have the opportunity to enroll in the one-half unit mathematics tutorial laboratory course. The subject content of the Basic Mathematics course would be the same as described above for the pre-algebra mathematics course except that the arithmetic of whole numbers and decimals would be treated in some detail.

These program elements would be integrated into the existing mathematics curriculum as displayed in the flowchart of Figure 10.

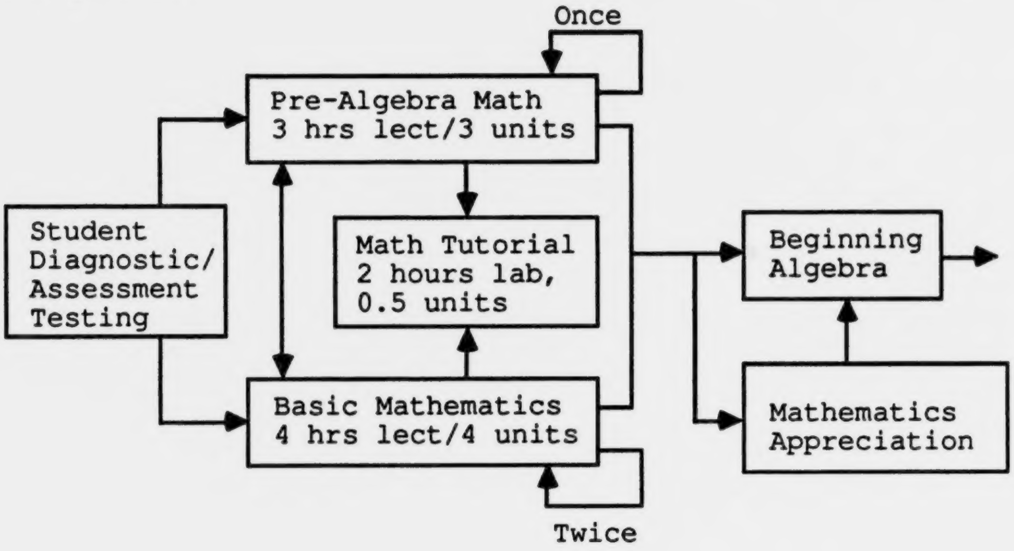
Once
Pre-Algebra Math
3 hrs lect/3 units
Student
Diagnostic/
Assessment
Testing
Math Tutorial
2 hours lab,
0.5 units
Beginning
Algebra
Basic Mathematics
4 hrs lect/4 units
Mathematics
Appreciation
Twice

Figure 10

Basic Mathematics Program Flowchart

Evaluation of Program Recommendations

The faculty recommendations resulting from the four round Delphi exercise were evaluated and found to be practical, complete, and consistent in terms of the program objectives, the educational environment at Saddleback College, and the practices of other California community colleges. A basic mathematics program composed of only two parallel arithmetic/introduction to algebra courses of different unit value was the practice previously adopted by six colleges: College of the Siskiyous, Foothill College, Laney College, San Diego City College, San Diego Mesa College, and San Diego Miramar College. The concept of offering the arithmetic/introduction to algebra class in both instructor-paced and student self-paced modes was not a unique concept to Saddleback College. Students at ten California colleges have the option of choosing between these methods. This was the case at Bakersfield College, Cerritos College, Fresno City College, Long Beach City College, College of Marin, Ohlone College, Orange Coast College, Pasadena City College, Solano College, and West Hills College. As has already been discussed and displayed in Table 7, twelve California college now offer a mathematics tutorial course of the type recommended by the Saddleback College mathematics faculty.

Program Cost Analysis

An analysis of the recommended program was executed from a financial viewpoint. The recommended program was found to be more cost effective than the the existing program at Saddleback College. Based on student attendance figures in basic mathematics for the 1988 spring term, the difference between state funds generated and expenditures for faculty salaries and benefits was found to be approximately $36,000. This same difference was calculated for one possible schedule arrangement of the recommended basic mathematics program and found to be approximately $61,000. This reflected a nearly seventy percent increase in net funds to the college. The description of the hypothesized schedule arrangement and calculations were placed in Appendix I.

Implementation of the recommended program would require no capital expenditures by the college. The computer software, audio taped and video taped lectures needed to support the tutorial and individualized instruction modes would be provided to the college at no charge by the publisher of the adopted textbook. The computers in the computer center and the media equipment in the library would be available to basic mathematics students. There were sufficient resources in these areas to meet the anticipated student demand. The tutorial class could be held in either the large open area between rooms 309 and 313 in the science/mathematics building or in that part of the computer center left vacant by the disposal of the large mainframe computer system. Neither of these areas were used as classrooms. Consequently, the designation of either area as the location of a tutoring activity would not impact the regular scheduling of classes to existing classrooms.

Chapter 5

INTERPRETATION, CONCLUSIONS, AND RECOMMENDATIONS

Placed in this chapter were an interpretation of the research results presented in the last chapter and the conclusions that were drawn from these results. Also discussed in this chapter were recommendations for the improvement of educational practice at Saddleback College. Included with these recommendations were strategies for implementation of these recommendations and diffusion of this information within Saddleback College and the two-year college mathematics education community as a whole.

Interpretation of Results

Review of the Basic Mathematics Programs in the California Community Colleges

The preferred organizational structure for the basic mathematics program in the California community colleges was to have it part of the mathematics department, This was the case in ninety-seven percent of the 105 degree granting colleges. While the basic mathematics courses were presented in three general categories, the most popular choice was an arithmetic class that included addition, subtraction, multiplication, and division using whole numbers, fractions, and decimals. This course also covered percent, applications, measurement, and (often) applied geometry. While sixty-five percent of the California colleges had such a course, forty-six percent had only this course in the basic mathematics curriculum. This course appeared to be the same arithmetic course that Kipps (1966:155) found was offered by eighty-five percent of the California community colleges in the 1965 fall term. Saddleback College opened in the 1967 fall term and chose this course for its basic mathematics program. Significantly fewer colleges shared this model with Saddleback College in 1988 than had, at its outset, in 1967.

A basic mathematics course that emerged after Kipps' (1966) study involved the content of the arithmetic course described above and an introduction to algebra including solution techniques for simple linear equations. This course was offered at forty-eight percent of the colleges and was the only basic mathematics course at twenty-eight percent of these institutions. Using the Delphi exercise in this study, the Saddleback College mathematics faculty agreed that it was this arithmetic/introduction to algebra course that should be offered and not the current course.

Generally the credit for basic mathematics courses had remained fairly constant since Kipps' (1966) study at three or fewer units, with the mode at three units. All colleges gave credit for these courses. Non-modular versions of the arithmetic course were granted four semester units at three of the sixty-eight colleges that offered this course. Non-modular versions of the arithmetic/introduction to algebra course were granted five semester units by three colleges and four units by three colleges of the fifty that offered this course. There was some support for the recommendation by Akst (1985:152) that the course be scheduled to meet at least four hours each week. This was the case at fourteen of the fifty-one colleges offering non-modular versions of the arithmetic course. This was also the case at fourteen of the forty-two colleges offering non-modular versions of the arithmetic/introduction to algebra course. Consequently, while there had been a reluctance to increase the unit credit for basic mathematics courses, there was a recognition that more than three hours each week was often necessary in this developmental program.

Survey of the Basic Mathematics Learning Environments Available in the California Community Colleges

The predominant format of basic mathematics instruction in the California community colleges involved a structured learning situation with instructor-paced, live lecture. This was consistent with the observations by Clute (1984:567), Warren (1985:71) and others that such a format was necessary for the success of many developmental students. This format was used at ninety-five colleges and was the only format available in sixty-one. Responding formally to the diversity of student learning characteristics thirty-four colleges gave students the option of enrolling in either an instructor-paced or student self-paced class and fifteen colleges allowed independent study. Ten colleges offered students only the self-paced option and this low number suggested agreement in California with the position taken by Dahlke (1975:188) that such programs were ineffective in arithmetic courses if not accompanied by a great deal of instructor support and guidance.

The overwhelming support given in the literature to the need to provide the opportunity for tutoring to basic mathematics students was matched by its availability in the California community colleges. It was formally present in some form in all but one college. Peer tutoring was used by ninety-six colleges and was the sole source of tutoring in fifty-one colleges. The use of peer tutors showed a recognition by college personnel of the advantages of this kind of tutoring for developmental students, as pointed out by Maxwell (1980:383) and others.

The growth in learning centers Cross (1976:11) observed in the early 1970s continued in the California community colleges. It was found that ninety-four percent of these colleges operated such centers in 1988. Mathematics learning centers were in existence at fifty-three percent of the California community colleges. This percent is significantly lower than the seventy-three percent figure determined by Alberding (1980:105) as a national figure for two-year colleges. The difference could have been due to a response bias (fifty-nine percent response rate) in his study and the designation, by the respondents, of a general college learning center supporting mathematics instruction as a mathematics learning center. In California thirty-seven colleges used the services of a mathematics learning center to support basic mathematics instruction while twenty-nine colleges used the general college learning center in this program.

The most often cited function of the learning center was tutoring, and this was consistent with the findings of Alberding (1983:105) and Campbell (1983:5). The next most often noted function of the learning center was computer-aided instruction currently available at forty-six colleges. To a lesser extent the center provided mediated instruction capability.

Computer-aided instruction was part of the basic mathematics program in forty-three colleges. Only twenty-two colleges provided audio taped or video taped lessons to support student learning in mathematics. The small number may have been due to an observation similar to those by Baley (1981:6) and Garrett (1987:2) that students rarely used these tapes. Those colleges that kept the tapes may have done so, as Alberding (1983:34) suggested, as a means of psychological support for the student.

Comparison of Basic Mathematics and Algebra Student Demographics

Several significant differences were found between the population of students enrolled in the developmental mathematics program and those enrolled in the college level algebra courses. The existence of these differences was important because members of the full-time faculty rarely taught the developmental course. They might have assumed that the student characteristics for the two groups were the same and responded in this design effort from that standpoint. A program designed on that premise may well have failed for many of the students in the developmental course.

It was found that, on the average, basic mathematics students were 4.5 years older than the algebra students. Basic Mathematics students were, on the average, in their late twenties. It was likely that these students had been away from formal mathematics education for a much longer period than those enrolled in algebra and were, therefore, somewhat anxious about returning to a mathematics classroom. Because of their increased age, basic mathematics students may well have had greater demands on their time by family, employment, and other extracurricular activities. These demands may affect the ability of many students to meet the requirements of a class organized around the traditional instructor-paced format.

For those continuing students enrolled in basic mathematics and algebra, there was no difference between the number of units earned at Saddleback College or the grade point average over those units. However, a significantly higher proportion of basic mathematics students were new to the college. While only seven percent of algebra students had no units completed at Saddleback College, fully twenty-five percent of the developmental students were new to the college. This was significant because, not only were many developmental students struggling to overcome math anxiety, many were totally unfamiliar with the college environment, rules, and procedures. The lack of understanding of routine administrative and class management matters may have added even more stress to attempts to master arithmetic in preparation for algebra.

Sex distributions of the arithmetic and algebra groups were significantly different. While one-half of the algebra group were women, two-thirds of the arithmetic students were women. This fact coupled with the difference in age between the two groups suggested the possibility that there was a large number of re-entry women who began collegiate studies, or at least the mathematics portion of it in the developmental course. They may well have had child care, employment, and other family responsibilities that were a high priority in their lives. Appreciation of this situation by the instructor would go a long way to reduce the stress these women felt with the often conflicting commitments of school, work, and family.

While the proportion of white, not Hispanic students in these two groups was not different, judgment was reserved on the question concerning the actual ethnic distribution. The raw ethnic distribution data were shown in Table 8. While the number of Hispanics in the two courses were essentially the same, the random sample of students in basic mathematics classes had no Asian students and five black. The random sample of students in the algebra classes had six Asian students and one black student. This difference in ethnic split, though not statistically significant at the 0.05 level, suggested the possibility of a concentration of those students usually associated with the academically disadvantaged in basic mathematics courses. This situation suggests that special student services may be necessary to ensure that the basic mathematics course does not become an obstacle to student enrollment in college level courses.

Saddleback College Program Recommendations

From the Delphi exercise it was clear that the mathematics faculty desired a program under their jurisdiction that would prepare the student for success in algebra. It was also agreed that the program material should include an introduction to algebra through use of signed numbers and linear equations. Support for this was not unanimous. Although three instructors opposed inclusion of these topics and three had no judgment, seven agreed that these were appropriate topics for the program. The decision was made to design the program consistent with the views of the majority.

The most needed support service for the basic mathematics program according to the mathematics faculty was students assessment and advisement. This capability was currently being developed by the college for all students, developmental and college level, and thus was not included in the program design. In support of the basic mathematics program, the faculty found live lectures, tutoring, a mastery learning environment, and a mathematics learning center to be very important. These were all components in many basic mathematics programs in the California community colleges and were both practical and achievable.

The specific program organization developed by the mathematics faculty called for two arithmetic/introduction to algebra courses and the support of a mathematics learning center. While the two courses would both cover material from the arithmetic of whole numbers through the solution of linear equations, each would be aimed at a different student group. One course, basic mathematics, would be directed at the weaker student or the student with severe mathematics anxiety. The course would meet four hours each week as recommended by Akst (1985:152). Although primarily a lecture class, it would allow a tutorial laboratory and a self-paced component in response to the diverse needs of these students. The second course, pre-algebra, would be addressed to the student needing a review or the student who possessed strong arithmetic computational skills. Little course time would be spent on the arithmetic of whole numbers and decimals. Although primarily an instructor-paced, live lecture class, it would allow a tutorial laboratory and a self-paced component in response to the diverse needs of students in basic mathematics.

One item that was placed on the fourth round Delphi questionnaire, after it appeared as a comment by a respondent to the round three questionnaire, had the potential of a major impact on the entire mathematics curriculum at Saddleback College. The faculty gave overwhelming support to the position that every mathematics course should have a required tutorial laboratory component. Because this item was directed at the entire curriculum and not specifically at the basic mathematics program, it was decided not to include a required tutorial laboratory in the proposed model. If this required component for every mathematics course were the wish of the faculty, it could be handled separately from this curriculum effort.

That this issue needs a thorough analysis was clear from the discussion in the literature review stressing the diversity of the students in the developmental mathematics program and the need to maintain the flexible nature of the program. To require a particular instructional mode for all students threatens the evoking of Snow's Law (see page 44) and creation of a situation where some students were benefited at the expense of others.

Program Cost Analysis

The cost of the proposed program was found to be potentially much less than the current program. While there was anticipated savings from a lower student attrition rates, these savings would be cancelled by the added cost of the self-paced component. The real producer of the savings was the optional tutorial laboratory course. This component should be promoted, not only for the financial health of the program, but the welfare of the students. However, requiring the laboratory appeared from the literature not to be in the best interest of all students. and should therefore be avoided, even if revenues to the college could be increased with such a practice.

Conclusions

Examination of the data generated in this research effort resulted in several conclusions. Students enrolled in community college basic mathematics programs represented a diverse group. At Saddleback College the average age of these students was 27.5 years. Two-thirds were women and twenty-five percent had no units completed at Saddleback College. These students needed access to a wide variety of instructional styles, including instructor-paced classes, a self-paced environment, and the opportunity for a laboratory experience supported by peer and faculty tutoring as well as computer-aided instruction materials.

The focus of the program should be to prepare students for success in algebra. This would best be accomplished by offering two version of the arithmetic/introduction to algebra course. One would meet four hours each week, and include a discussion of the arithmetic of whole numbers and decimals in some detail. The other course would meet three hours each week, and only briefly mention the arithmetic of whole numbers and decimals before beginning a detailed discussion of the arithmetic of fractions. Both courses would cover the traditional arithmetic topics and end with the solution techniques for simple linear equations. Under either class, students should have access to a structured self-paced environment (not independent study). Under either class students should be able to enroll in an optional mathematics tutorial laboratory that would include computer-aided instruction activities. This laboratory experience would aid their efforts to grasp the principals of arithmetic and an introduction to algebra. The program as described was found to be cost effective and had the potential of lowering the cost to the college for developmental mathematics.

Recommendations for the Improvement of Educational Practice

Implementation of the proposed developmental mathematics program would immediately and significantly improve the educational practice in that segment of the curriculum. The significance of this study was not limited to the reform efforts at Saddleback College. Mathematics instructors from sixty-seven of the 105 degree granting California community colleges expressed an interest in receiving a summary of the results. A mathematics professor at one college reported that a proposal for funding a similar study of the basic mathematics program at his college had recently been submitted to the board of trustees. The results of the Saddleback College study were sought as a means to prevent "reinventing the wheel" in this area and to stand as a foundation for their own study (Brudos, 1988).

The pending statewide change in the applicability of arithmetic to the associate degree, already implemented at Saddleback College, has broadened the significance of this study. It was expected that the results would be of value to educators throughout California interested in the conduct of remedial education in the community colleges. Further, it was expected to serve as a foundation and guide for those colleges, like Saddleback College, that sought to make programmatic changes.

Strategies for Diffusion

The results of this Major Applied Research Project will be shared with the Saddleback College mathematics faculty in a group meeting as soon as is feasible following project completion. A summary will be sent to the colleagues at each of the sixty-seven California community colleges who requested this information. This summary will also be sent to the Education Resources Information Center (ERIC) for possible inclusion in that system. The information will be shared with the Board of Trustees of the Saddleback Community

College District and District faculty through the completion of the required sabbatical leave report. An abstract will be sent to the presenter chair for the American Mathematics Association for Two-year Colleges Fifteenth Annual Convention in Baltimore (MD) in October, 1989 for possible inclusion in the seminar program. Similarly, an abstract will be sent to the presenter chair for the California Mathematics Council for Community Colleges -- South Annual Convention in Newport Beach (CA) in March, 1990. A summary of the research effort will be forwarded to a national mathematics education journal.

Strategies for Implementation

When the mathematics department meets to be briefed on the results of this study, a complete set of curriculum revision documents will be presented. Revisions to the program proposal requested by the mathematics department will be incorporated into these documents. If department approval is received, the proposal will be carried to division level and college level. Appropriate revisions will be made as required by these administrative groups.

Strategies for Improvement

One year following implementation of this program the mathematics faculty will meet to review the program. Student attrition, percent of students receiving grades C or higher, and enrollment levels will be compared with the current program. Faculty satisfaction with the program will be ascertained and recommendations for the improvement of the program discussed. Revisions with department support will be prepared on the appropriate curriculum documents and forwarded to the division and college level for approval.

Significance of the Project

This Major Applied Research Project has made a significant contribution to the improvement of the educational program at Saddleback College. It has served to instruct the mathematics faculty about a program component with which few were knowledgeable and has drawn attention to the needs of students enrolled in basic mathematics. Realization, by the faculty, of the need for a variety of instructional styles in these courses lead to provisions for laboratory space, a mediated learning classroom, and computer-aided learning facilities in the proposed science/mathematics building addition. Though included primarily for the use of basic mathematics students, these features have the potential for use in every part of the mathematics curriculum. Consequently, the impact of this study may well extend far beyond the limited scope of its stated purpose.

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APPENDIX A

LEARNING ENVIRONMENTS SURVEY

PILOT VERSION

April 22, 1988

Dear Colleague:

The mathematics department at Saddleback College is currently attempting to revise the pre-algebra portion of its curriculum to best serve the students of the college. We would like to identify those learning environments other community colleges have found appropriate for their students at this level. Your opinion and the experiences at your college are very important to our study. Please help us by completing the attached questionnaire or passing it along to someone who would be able to complete it. If you would like a summary of the results of this project, please place your name and address in the upper left-hand corner of the reverse side of the questionnaire.

Sincerely,

Steve Sworder,
Mathematics

SADDLEBACK COLLEGE

Arithmetic/Pre-algebra Learning Environments Survey

Please indicate those modes of instruction, learning support services, and course formats available to students enrolled at your college in basic mathematics courses at the arithmetic or pre-algebra level by placing a check mark in the space provided to the left of the item description. Simply leave the space blank for those items not available. Please add any comments you feel will help us benefit from your experiences in this area.

If you would like a summary of the results of this study, please place your name and address in the upper left-hand corner of the reverse side of the questionnaire. Once the questionnaire has been completed, please remove this cover letter and place the questionnaire in the U.S. mail. It has been pre-addressed and pre-stamped.

THANK YOU!

The following abbreviations are used in the questionnaire:

CAI -- computer assisted instruction
Math LC -- mathematics learning center or mathematics laboratory
College LC -- college learning center that addresses other subjects as well as mathematics

The phrase "mastery learning" used with the "Course Format" section refers to the practice of requiring the student to demonstrate mastery or competence in a unit of material before being allowed to move on to the next unit for study. The phrase "independent study" also used in that section refers to a course format that does not call for class meetings or give required completion dates for course assignments or examinations.

QUESTIONNAIRE

INSTRUCTIONAL DELIVERY MODES:

___Lectures: ___live, ___videotaped, ___audiotaped

___Group Discussions: led by ___faculty, ___paraprofessional, ___student aide

___Written Material: ___standard text, ___programmed text, ___workbook,
___instructor prepared handouts

___CAI: ___stations tied to a mainframe, ___stand alone stations
Location: ___Classroom, ___Math LC, ___College LC

LEARNING SUPPORT SERVICES:

___Tutoring: by whom? ___peers, ___paraprofessional, ___faculty (besides office hrs)
where? ___classroom, ___Math LC, ___College LC, ___other

___Learning Center: type: ___Math LC, ___College LC
attendance: ___open/walk-in, ___regularly scheduled for student,
___required as part of the course, ___ADA collected
functions: ___tutoring, ___CAI, ___mediated instruction,
___diagnostic testing, ___course testing

COURSE FORMAT:

___ open entry/open exit, ___mastery learning, ___independent study,

___ variable credit or credit for completion of individual course modules

___ "in progress" grade available

ANY COMMENTS OR ADDITIONAL INSTRUCTIONAL MODES, SUPPORT SERVICES, OR FORMAT OPTIONS:

APPENDIX B

LEARNING ENVIRONMENTS SURVEY

FINAL VERSION

May 10, 1988

Dear Colleague:

The mathematics department at Saddleback College is revising the pre-algebra portion of its curriculum to best serve the needs of the students or our college. We would like to identify those learning environments other community colleges have found appropriate for their students at this level.

Your opinion and the practices at your college are very important to our study. Please help us by completing the attached questionnaire before June 1 or passing it along to someone who would be able to complete it by that date. The questionnaire requires only check mark responses. It has been placed on one side of a pre-addressed, postage paid postcard for your convenience.

If you would like a summary of the results of this project, please place your name and address on the mailing label in the upper left-hand corner of the reverse side of the questionnaire. We will hopefully be ready to share the final report with you sometime early this fall. Thank you for your help and hope you have a good summer.

Sincerely,

Steve Sworder
Mathematics Department
(714) 582-4316

SADDLEBACK COLLEGE

Arithmetic/Pre-algebra Learning Environments Survey

Please indicate those modes of instruction, course formats, and learning support services available to students enrolled at your college in basic mathematics courses at the arithmetic or pre-algebra level by placing a check mark in the space provided to the left of the item description. Simply leave the space blank for those items not available. Please add any comments you feel will help us benefit from your experiences in this area. Once the questionnaire has been completed, please remove this cover letter and place the questionnaire in the U.S. mail. It has been pre-addressed and pre-stamped.

The following abbreviations are used in the questionnaire:

CAI -- computer assisted instruction

Math LC -- mathematics learning center or mathematics laboratory

College LC -- college learning center that addresses other subjects as well as mathematics

The phrase "mastery learning" used with the "Course Formats" section refers to the practice of requiring the student to demonstrate mastery or competence in a unit of material before being allowed to move on to the next unit for study.

The phrase "independent study" also used in that section refers to a format in which students enroll in a course section, but those students do not meet with the instructor as a group or have class deadlines for completion of assignments or examinations.

QUESTIONNAIRE

Please check ALL that apply to the Arithmetic/Pre-algebra Course

INSTRUCTIONAL DELIVERY MODES:

Lectures: ___ none, ___ live, ___ videotaped, ___ audiotaped

Written Material: ___ none, ___ standard (not programmed) text, ___ programmed text,
___ workbook, ___ instructor prepared handouts

CAI: ___ none, ___ stations tied to a mainframe, ___ stand alone stations

Delivery Locations: ___ classroom, ___ Math LC, ___ College LC

COURSE FORMATS:

___ "traditional" (instructor paced), ___ open entry/open exit, ___ mastery learning,

___ independent study, ___ "in progress" grade available,

___ student is completely free to self-place in any course format available

___ variable credit or credit for completion of individual course modules

LEARNING SUPPORT SERVICES:

Group Workshops/Discussions: ___ none; led by ___ faculty (besides during office hrs),
___ paraprofessional, ___ student aide

Tutoring: ___ none; by whom? ___ faculty (besides during office hours),
___ paraprofessional, ___ peers/student aides

location? ___ classroom, ___ Math LC, College LC, ___ other

Learning Center: ___ none; type: ___ Math LC, ___ College LC

attendance: ___ open/walk-in, ___ regularly scheduled for student,
___ required as part of the course, ___ ADA collected

functions: ___ tutoring, ___ CAI, ___ mediated instruction,
___ diagnostic testing, ___ course testing

Please note any comments or additional instructional modes, format options, or support services in the space provided on the left portion of the reverse side of this card.

THANK YOU!

APPENDIX C

FIRST ROUND DELPHI COVER LETTER AND QUESTIONNAIRE

October 18, 1988

Dear ,

Thank you for your willingness to participate in this review of our basic mathematics program. It is anticipated that, through your efforts, those revisions necessary to carry this portion of the mathematics curriculum strongly into the 1990s will be identified. The curriculum review project will involve a four-part Delphi exercise and this document represents the first round of that exercise.

After an exhaustive review of the literature dealing with remedial/developmental mathematics, it is clear that there is no magical formula for success. Almost every instructional method imaginable has been shown to be successful with some students and not successful with others. Remedial students seem to generally thrive in environments of personal attention and those created by a caring and dedicated faculty/support staff. Access to tutoring has consistently been shown to be important to skill and attitude improvement in these students.

To gain a statewide perspective on the arithmetic/pre-algebra program at the community college level, a survey was conducted of these programs in California. A questionnaire was sent to each mathematics department chair and the program description in the catalog of each college studied. This investigation revealed that every college offered an basic mathematics program and that this program resided within the mathematics department in all but three colleges. The California community colleges have implemented a wide variety of organizational forms for the basic mathematics programs. Courses ranged in unit value from one to eight. A course of three units was the most prevalent. The variation of class hours was also great. Straight lecture classes ranged from one to five hours per week, but those that met three hours were most common. Lecture/laboratory combinations came in many variations. Among the many options used by the California colleges were six hours lecture/lab, two hours lecture/three hours lab, three hours lab, and eight hours lab.

The courses in the basic mathematics program fell into three basic categories: (1) Arithmetic Fundamentals: addition, subtraction, multiplication, and division using whole numbers, fractions, and (usually) decimals; (2) Arithmetic: included the contents of the arithmetic fundamentals course noted above along with the topics of percents, applications, measurement, and (often) applied geometry; (3) Arithmetic/Introduction to Algebra: included the contents of the arithmetic course noted above, along with an introduction to algebra including the solution techniques for simple linear equations. The arithmetic fundamentals course was offered at twelve colleges, sixty-eight colleges offered the arithmetic course, and fifty colleges offered the arithmetic/introduction to algebra course. The arithmetic fundamentals and the arithmetic courses were both offered at four colleges. The arithmetic fundamentals and arithmetic/introduction to algebra courses were both offered at five colleges. The arithmetic and arithmetic/introduction to algebra courses were both offered at sixteen colleges. No college offered all three courses. The distribution of basic mathematics courses among the California community colleges was placed in the Venn diagram of Figure 1.

These courses were not always represented in the curriculum by single distinct classes. A sequence of courses was occasionally used to complete the material in one of the categories noted above. Often courses were organized around a modular format. The student earned units as competency in modules or parts of the entire class were satisfactorily demonstrated. When all modules had been completed, full course credit was awarded. Classes were offered in lecture formats, laboratory formats, and combinations of the two as described below. They were available in traditional instructor- or class-paced, self-paced, or individualized forms. Independent study courses were available at fifteen schools.

Live lectures on this material were offered at ninety-one colleges while eight colleges provided no lectures (live or taped) on the material. In Figure 2 is presented a Venn diagram for the distribution of media use in the basic mathematics program among the colleges. In sixty-one colleges the traditional instructor-paced class was the only format available to students. All but one school indicated the availability of tutoring. Students were employed as tutors at ninety-six colleges. A mathematics learning center was in existence at fifty-six schools and ninety-nine had either a mathematics learning center, a college learning center, or both. An open lab format that allowed students to drop in at their convenience for assistance was available at sixty-seven colleges.

Since generally the Saddleback College mathematics faculty has had more contact with algebra students than with those students enrolled in basic mathematics, it was felt that a more informed program review could be conducted if differences between these two student populations were identified. A random sample of Basic Mathematics students and a separate random sample Beginning and Intermediate Algebra students enrolled during the 1988 spring semester were selected and studied. The mean age of arithmetic students was found to be 27.0 while the sample of algebra students had a mean age of 22.5. This difference was shown to be statistically significant. However, there was found to be no significant difference between the cumulative grade point averages of continuing students in these two groups nor the ethnic distribution of the students in these groups. The sample of basic mathematics students had a significantly higher proportion of female students (sixty-seven percent versus fifty percent) and of new students to the college (twenty-five percent versus seven percent).

Now direct your attention to the attached questionnaire. Please answer every question and return the completed questionnaire by 3:00 p.m. Monday, October 24, 1988. The results from all of the questionnaires will be tabulated and returned to you for review and reconsideration of your responses as round two of the Delphi exercise. Thank you again for your help with this curriculum review project. The time and effort you are expending will greatly benefit our students and program.

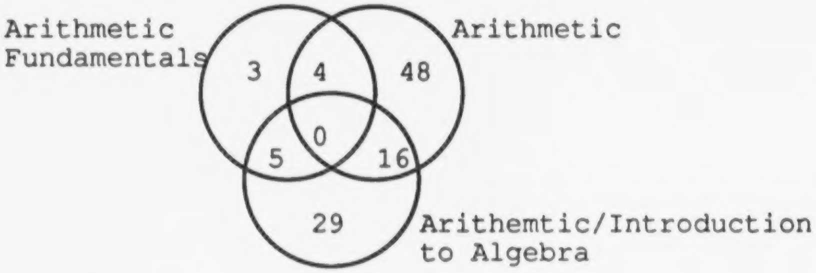
Arithmetic Fundamentals
Arithmetic
3
4
48
0
5
16
29
Arithemtic/Introduction to Algebra

Figure 1

Distribution of the Basic Mathematics Courses
Among the California Community Colleges

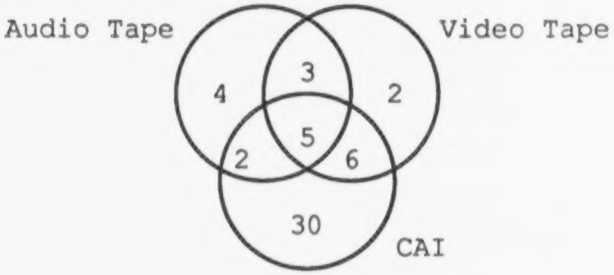
Audio Tape
Video Tape
4
3
2
5
2
6
30
CAI

Figure 2

Distribution of Media Used for Basic
Mathematics Among the Colleges

Mathematics Department
Saddleback College
Basic Mathematics Program Survey
Delphi Exercise Round One

I. PROGRAM OBJECTIVES

Indicate the level of importance each of the following objectives should hold for an basic mathematics program at Saddleback College. Do this by circling the appropriate abbreviation: NJ (no judgment); UI (unimportant); SI (slightly important); I (Important); VI (very important).

A. Help the student develop good study habits. NJ UI SI I VI

B. Prepare the student for success in algebra. NJ UI SI I VI

C. Improve the student's self-image. NJ UI SI I VI

D. Aide the student to become functional on the job and in day-to-day life. NJ UI SI I VI

E. Screen out those students who will not be successful in college level work and dissuade their continuance. NJ UI SI I VI

F. Improve a student's arithmetic skills to whatever level possible even though the student may never succeed at college level work. NJ UI SI I VI

G. Encourage the full mental, moral, and emotional growth of the student. NJ UI SI I VI

H. Enrich the life of the student. NJ UI SI I VI

I. Please list in order the three objectives that should be most important for the basic mathematics program at Saddleback College. These may be chosen from the list above or be other objectives not yet mentioned.

1.

2.

3.

II. PROGRAM ORGANIZATION

Indicate your level of agreement with each of the following statements concerning the possible organization of a Saddleback College basic mathematics program. Do this by circling the appropriate abbreviation: NJ (no judgment); SD (strongly disagree); D (disagree); A (agree); SA (strongly agree).

A. No basic mathematics program should exist at Saddleback College NJ SD D A SA

B. The basic mathematics program should be offered by the College through a special developmental skills department separate from the mathematics department. NJ SD D A SA

C. The basic mathematics program should be offered through the mathematics department. NJ SD D A SA

D. This program should consist of a single one semester course. NJ SD D A SA

E. A student enrolled in this program should have a variety of instructional styles from which to choose. NJ SD D A SA

F. The course(s) in this program should be offered only in the lecture/discussion instructor-paced format. NJ SD D A SA

G. The student enrolled in this program should be able to proceed through the instructional materials at their own pace (i.e. the course is student self-paced). NJ SD D A SA

H. The instructional materials should begin with counting and operations with whole numbers and then continue with more advanced topics. NJ SD D A SA

I. The instructional materials should begin with common fractions and then continue with more advanced topics. NJ SD D A SA

J. The instructional materials should not include any topic presented in beginning algebra. NJ SD D A SA

K. The instructional materials should include the arithmetic of signed numbers. NJ SD D A SA

L. The instructional materials should include the solution of linear equations. NJ SD D A SA

M. The program materials should include operations with polynomials. NJ SD D A SA

N. Please list in order the three features you feel are most important for the organization of the basic mathematics program at Saddleback College. These features may appear above or be features not yet mentioned.

1.

2.

3.

III. LEARNING AND INSTRUCTIONAL SUPPORT SERVICES

Indicate the level of importance the availability of each of the following services should hold for the participants (students and instructors) of an basic mathematics program at Saddleback College. Do this by circling the appropriate abbreviation: NJ (no judgment); UI (unimportant); SI (slightly important); I (important); VI (very important).

A. Tutoring during regular class time. NJ UI SI I VI

B. Drop-in tutoring outside class. NJ UI SI I VI

C. Scheduled tutoring outside class. NJ UI SI I VI

D. Live lectures. NJ UI SI I VI

E. Taped lectures. NJ UI SI I VI

F. Computer-Aided Instruction. NJ UI SI I VI

G. Mediated instruction via programmed text, video tapes, audio tapes, or other media form. NJ UI SI I VI

H. Independent study. NJ UI SI I VI

I. A mastery learning environment. NJ UI SI I VI

J. An open entry/open exit enrollment option. NJ UI SI I VI

K. Tutoring by mathematics department faculty in addition to their regularly scheduled office hours.	NJ	UI	SI	I	VI
L. Convenient student group study areas outside the classroom.	NJ	UI	SI	I	VI
M. Student assessment/diagnostic testing.	NJ	UI	SI	I	VI
N. Regular course testing (first time or make-up) outside of the regular class time.	NJ	UI	SI	I	VI
O. Follow-up research on student success in college level courses.	NJ	UI	SI	I	VI
P. Student advisement/counseling.	NJ	UI	SI	I	VI

Q. Please list in order the three services that should be most important for the basic mathematics program at Saddleback College. These may be services that appear above or other services not yet mentioned.

1.

2.

3.

THE END

APPENDIX D

SECOND ROUND DELPHI COVER LETTER AND QUESTIONNAIRE

October 26, 1988

Dear ,

Thank you again for your willingness to participate in this review of our basic mathematics program. Your contributions are critical to the effectiveness of any curriculum modifications we make to this portion of our program. The Delphi round two questionnaire is attached. Immediately following each item that was on the round one questionnaire, in parentheses, are given the number (thirteen maximum) of mathematics faculty who responded other than "NJ" and the mean response for that item. The symbols "+" and "-" have the same meaning as we use when grading students. The symbol "+" means a little more than the base and the symbol "-" means a little less than the base. Your individual responses from round one were shaded with a broad tipped pen. Those new items suggested for inclusion during the round one exercise have been added and are marked with an asterisk (*) in the left margin.

Please complete the round two questionnaire. If you wish to change your response from the round one survey simply circle the desired response. If you do not want to change your previous position, no action is necessary. Please return the completed questionnaire by 3:00 p.m. Wednesday, November 2, 1988.

Thank you,

Mathematics Department
Saddleback College
Basic Mathematics Program Survey
Delphi Exercise Round Two

I. PROGRAM OBJECTIVES

Indicate the level of importance each of the following objectives should hold for an basic mathematics program at Saddleback College. Do this by circling the appropriate abbreviation: NJ (no judgment); UI (unimportant); SI (slightly important); I (Important); VI (very important).

A. Help the student develop good study habits. (13,I+) NJ UI SI I VI

B. Prepare the student for success in algebra. (12,VI-) NJ UI SI I VI

C. Improve the student's self-image. (13, I+) NJ UI SI I VI

D. Aid the student to become functional on the job and in day-to-day life. (13,I+) NJ UI SI I VI

E. Screen out those students who will not be successful in college level work and dissuade their continuance. (13,UI) NJ UI SI I VI

F. Improve a student's arithmetic skills to whatever level possible even though the student may never succeed at college level work. (13,I) NJ UI SI I VI

G. Encourage the full mental, moral, and emotional growth of the student. (12,I-) NJ UI SI I VI

H. Enrich the life of the student. (10,I) NJ UI SI I VI

*I. Develop problem solving abilities in the student NJ UI SI I VI

*J. Develop an understanding of the processes of arithmetic (i.e. why the rules work) NJ UI SI I VI

*K. Develop "number sense"--the ability to judge whether an answer is reasonable or ridiculous. NJ UI SI I VI

*L. Develop computational skills. NJ UI SI I VI

*M. Demonstrate a usefulness for math through relevant examples NJ UI SI I VI

*N. Reduce math anxiety NJ UI SI I VI

*O. Comprehensive knowledge of course material should be stressed on all exams. NJ UI SI I VI

II. PROGRAM ORGANIZATION

Indicate your level of agreement with each of the following statements concerning the possible organization of a Saddleback College basic mathematics program. Do this by circling the appropriate abbreviation: NJ (no judgment); SD (strongly disagree); D (disagree); A (agree); SA (strongly agree).

A. No basic mathematics program should exist at Saddleback College. (13,SD-) NJ SD D A SA

B. The basic mathematics program should be offered by the College through a special developmental skills department separate from the mathematics department. (12,SD-) NJ SD D A SA

C. The basic mathematics program should be offered through the mathematics department. (12,SA) NJ SD D A SA

D. This program should consist of a single one semester course. (12,SA) NJ SD D A SA

E. A student enrolled in this program should have a variety of instructional styles from which to choose. (13,SA-) NJ SD D A SA

F. The course(s) in this program should be offered only in the lecture/discussion instructor-paced format. (13,D+) NJ SD D A SA

G. The student enrolled in this program should be able to proceed through the instructional materials at their own pace (i.e. the course is student self-paced). (13,A) NJ SD D A SA

H. The instructional materials should begin with counting and operations with whole numbers and then continue with more advanced topics. (13,A) NJ SD D A SA

I. The instructional materials should begin with common fractions and then continue with more advanced topics. (13,D) NJ SD D A SA

J. The instructional materials should not include any topic presented in beginning algebra. (12,SD-) NJ SD D A SA

K. The instructional materials should include the arithmetic of signed numbers. (13,A+) NJ SD D A SA

L. The instructional materials should include the solution of linear equations. (13,A) NJ SD D A SA

M. The program materials should include operations with polynomials. (11,D+) NJ SD D A SA

*N. The program should include an arithmetic course as well as a pre-algebra course. NJ SD D A SA

*O. The program should set a work level that requires a collegiate commitment, even if the work is not college level. NJ SD D A SA

*P. A method of testing for learning disabilities should be provided NJ SD D A SA

*Q. Special Services should handle those students with identified learning disabilities. NJ SD D A SA

*R. The instructional materials should provide for a strong foundation in fractions. NJ SD D A SA

*S. The instructional materials should include many applied examples NJ SD D A SA

*T. The program should be structured somewhere between self-paced and instructor-paced. NJ SD D A SA

*U. Courses in this program should be taught by caring and interested instructors NJ SD D A SA

*V. The program should be instructor paced, since human contact is essential and there is need for a more "controlled" environment. NJ SD D A SA

*W. The program should be offered in both the instructor paced and self-paced formats NJ SD D A SA

*X. Each assignment should give sufficient practice on new topics to draw out common errors, but each assignment should also have substantial review included. NJ SD D A SA

*Y. Cumulative tests at least at the end of each chapter should be given NJ SD D A SA

*Z. The program should include the beginning translation of words to math symbols (e.g. Three more than twice a number means 2x+3) NJ SD D A SA

III. LEARNING AND INSTRUCTIONAL SUPPORT SERVICES

Indicate the level of importance the availability of each of the following services should hold for the participants (students and instructors) of an basic mathematics program at Saddleback College. Do this by circling the appropriate abbreviation: NJ (no judgment); UI (unimportant); SI (slightly important); I (important); VI (very important).

A. Tutoring during regular class time. (11,SI+) NJ UI SI I VI

B. Drop-in tutoring outside class. (13,I+) NJ UI SI I VI

C. Scheduled tutoring outside class. (13,I+) NJ UI SI I VI

D. Live lectures. (13,VI-) NJ UI SI I VI

E. Taped lectures. (13,I-) NJ UI SI I VI

F. Computer-Aided Instruction. (13,I) NJ UI SI I VI

G. Mediated instruction via programmed text, video tapes, audio tapes, or other media form. (13,I+) NJ UI SI I VI

H.	Independent study. (12,SI)	NJ	UI	SI	I	VI
I.	A mastery learning environment. (10,VI-)	NJ	UI	SI	I	VI
J.	An open entry/open exit enrollment option. (12,I)	NJ	UI	SI	I	VI
K.	Tutoring by mathematics department faculty in addition to their regularly scheduled office hours. (12,I)	NJ	UI	SI	I	VI
L.	Convenient student group study areas outside the classroom. (13,VI-)	NJ	UI	SI	I	VI
M.	Student assessment/diagnostic testing. (13,VI)	NJ	UI	SI	I	VI
N.	Regular course testing (first time or make-up) outside of the regular class time. (11,SI-)	NJ	UI	SI	I	VI
O.	Follow-up research on student success in college level courses. (13,I)	NJ	UI	SI	I	VI
P.	Student advisement/counseling. (13,VI)	NJ	UI	SI	I	VI
*Q.	Student advisement/counseling by math faculty, rather than by counselors, through released time assignments.	NJ	UI	SI	I	VI
*R.	Diagnostic testing with results available to the student and instructor during the first week of class.	NJ	UI	SI	I	VI
*S.	An open entry/open exit enrollment option with a "satisfactory progress" requirement should exist. The student would be limited to a two semester or one semester plus summer period.	NJ	UI	SI	I	VI
*T.	Availability of both peer and faculty tutoring.	NJ	UI	SI	I	VI
*U.	Scheduled tutoring outside class supplemented by a variety of instructional support services	NJ	UI	SI	I	VI
*V.	A math lab that is open as many hours as possible.	NJ	UI	SI	I	VI

THE END

APPENDIX E

SECOND ROUND DELPHI EXERCISE RESULTS

RANK ORDER OF BASIC MATHEMATICS PROGRAM OBJECTIVES, ORGANIZATION, AND SUPPORT SERVICES
Delphi Round Two -- Results

Element	value	mean	rank
Objectives:			
B. Prepare the student for success in algebra.	VI	3.77	1
A. Help the student develop good study habits.	VI-	3.62	2
K. Develop "number sense"--the ability to judge whether an answer is reasonable or ridiculous.	VI-	3.62	3
I. Develop problem solving abilities in the student.	I+	3.46	4
C. Improve the student's self-image.	I+	3.38	5
D. Aide the student to become functional on the job and in day-to-day life.	I+	3.38	5
F. Improve a student's arithmetic skills to whatever level possible even though the student may never succeed at college level work.	I+	3.38	5
L. Develop computational skills.	I	3.23	8
N. Reduce math anxiety.	I	3.23	8
M. Demonstrate a usefulness for math through relevant examples.	I	3.23	8
G. Encourage the full mental, moral, and emotional growth of the student.	I	3.00	11
J. Develop an understanding of the processes of arithmetic (i.e. why the rules work).	I	3.00	11
H. Enrich the life of the student.	I	2.92	13
O. Comprehensive knowledge of course material should be stressed on all exams.	I	2.92	13
E. Screen out those students who will not be successful in college level work and dissuade their continuance.	UI	1.23	15

Element	value	mean	rank
Organization:			
U. Courses in this program should be taught by caring and interested instructors.	SA	3.85	1
C. The basic mathematics program should be offered through the mathematics department.	SA	3.77	2
E. A student enrolled in this program should have a variety of instructional styles from which to choose.	SA-	3.69	3
K. The instructional materials should include the arithmetic of signed numbers.	SA-	3.54	4
R. The instructional materials should provide for a strong foundation in fractions.	A+	3.46	5
S. The instructional materials should include many applied examples	A+	3.31	6
W. The program should be offered in both the instructor paced and self-paced formats.	A+	3.30	7
O. The program should set a work level that requires a collegiate commitment, even if the work is not college level.	A+	3.25	8
H. The instructional materials should begin with counting and operations with whole numbers and then continue with more advanced topics.	A	3.23	9
X. Each assignment should give sufficient practice on new topics to draw out common errors, but each assignment should also have substantial review included.	A	3.18	10
G. The student enrolled in this program should be able to proceed through the instructional materials at their own pace (i.e. the course is student self-paced).	A	3.15	11

Element	value	mean	rank
P. A method for testing for learning disabilities should be provided	A	3.15	11
Z. The program should include the beginning translation of words to math symbols (e.g. Three more than twice a number means 2x+3).	A	3.08	13
Q. Special services should handle those students with identified learning disabilities.	A	3.08	13
T. The program should be structured somewhere between self-paced and instructor-paced.	A	3.00	15
N. The program should include an arithmetic course as well as a pre-algebra course.	A	2.92	16
Y. Cumulative tests at least at the end of each chapter should be given.	A	2.92	16
D. This program should consist of a single one semester course.	A	2.83	18
V. The program should be instructor paced, since human contact is essential and there is need for a more "controlled" environment.	A	2.77	19
L. The instructional materials should include the solution of linear equations.	A	2.76	20
Seven instructors responded A or SA; three instructors responded D or SD.			
I. The instructional materials should begin with common fractions and then continue with more advanced topics.	D+	1.69	21
M. The program materials should include operations with polynomials.	D+	1.75	22
F. The course(s) in this program should be offered only in the lecture/discussion instructor-paced format.	D+	1.54	23
J. The instructional materials should not include any topic presented in beginning algebra.	SD-	1.33	24

Element	value	mean	rank
B. The basic mathematics program should be offered by the College through a special developmental skills department separate from the mathematics department.	SD-	1.31	25
A. No basic mathematics program should exist at Saddleback College	SD	1.23	26
Support Services:			
M. Student assessment/diagnostic testing.	VI	3.92	1
P. Student advisement/counseling.	VI	3.85	2
R. Diagnostic testing with results available to the student and instructor during the first week of class.	VI	3.77	3
V. A math lab that is open as many hours as possible.	VI	3.75	4
D. Live lectures.	VI-	3.62	5
B. Drop-in tutoring outside class.	VI-	3.62	5
L. Convenient student group study areas outside the classroom.	VI-	3.62	5
T. Availability of both peer and faculty tutoring.	VI-	3.54	8
I. A mastery learning environment.	VI-	3.50	9
U. Scheduled tutoring outside class supplemented by a variety of instructional support services.	I+	3.46	10
G. Mediated instruction via programmed text, video tapes, audio tapes, or other media form.	I+	3.31	11
C. Scheduled tutoring outside class.	I+	3.30	12
F. Computer-Aided Instruction.	I	3.23	13
Q. Student advisement/counseling by math faculty, rather than by counselors, through released time assignments.	I	3.17	14
J. An open entry/open exit enrollment option.	I	3.08	15

Element	value	mean	rank
O. Follow-up research on student success in college level courses.	I	3.00	16
E. Taped lectures.	I	2.77	17
K. Tutoring by mathematics department faculty in addition to their regularly scheduled office hours.	I	2.75	18
S. An open entry/open exit enrollment option with a "satisfactory progress" requirement should exist. The student would be limited to a two semester or one semester plus summer period.	I-	2.62	19
A. Tutoring during regular class time.	SI+	2.33	20
H. Independent study.	SI	2.08	21
N. Regular course testing (first time or make-up) outside of the regular class time.	SI	1.82	22

APPENDIX F

THIRD ROUND DELPHI COVER LETTER
AND QUESTIONNAIRE

November 7, 1988

Dear ,

The results of round two of the Delphi exercise dealing with the basic mathematics program at Saddleback College have been attached for your information. These results are in the package printed on gray paper and are the foundation for the remaining two rounds of this exercise. Using the information from round two, a candidate program was designed and placed in the attached package printed on green paper.

For round three of this Delphi effort, please look through the candidate basic mathematics program (green package) and indicate your agreement, disagreement, or desire not to give a judgment at this time. This is accomplished by checking the appropriate box. In the space below the line of each item, please add any comments that you feel would be helpful. Your responses should be based on the pedagogical merit you see in each item and not on physical, administrative, or contractual constraints that might currently exist at Saddleback College. Once the optimum basic mathematics program has been identified, other exterior factors will be integrated with it to produce the best possible curriculum proposal for your ultimate consideration.

Please complete the round three questionnaire (green package) and return it by 3:00 p.m. Monday, November 14, 1988. Thanks again for your perseverance.

Sincerely,

Mathematics Department
Saddleback College
Basic Mathematics Program Study
Delphi Round Three: A Candidate Program

Please respond to the following questionnaire items by checking NJ if you have no judgment at this time, A if you agree, and D if you disagree.

The basic mathematics program at Saddleback College should be composed of the following components:

	NJ	A	D
1) Course: If you feel this course should not be offered, check D and skip to component 2.	☐	☐	☐
Title: Pre-Algebra Mathematics	☐	☐	☐
Units: 3	☐	☐	☐
Prerequisite: Satisfactory score on the mathematics assessment examination	☐	☐	☐
Repeatable: 0 times	☐	☐	☐
Content:			
Brief review of the arithmetic of whole numbers and decimals	☐	☐	☐
The arithmetic of common fractions	☐	☐	☐
Ratios and proportions, percent, and scientific notation	☐	☐	☐
Calculator skills	☐	☐	☐
Perimeters, areas, and volumes of common geometric figures	☐	☐	☐
Powers and roots	☐	☐	☐
Arithmetic of signed numbers	☐	☐	☐
Solutions of simple linear equations and formulas	☐	☐	☐
Translation of word phrases to mathematical expressions	☐	☐	☐

	NJ	A	D
Word problems and problem solving techniques	☐	☐	☐

Additional content items (Please list in the order of importance.):

1.

2.

3.

Instructional formats available:

3 hours lecture	☐	☐	☐
3 hours lecture/2 hours laboratory--In addition to the regular 3 hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	☐	☐	☐
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	☐	☐	☐
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	☐	☐	☐

Please list, in order of importance, other desirable instructional formats that should be offered:

1.

2.

3.

2) Course:	☐	☐	☐

If you feel this course should not be offered, check D and skip to component 3.

Title: Basic Mathematics	☐	☐	☐
Units: 5	☐	☐	☐
Prerequisite: None	☐	☐	☐

	NJ	A	D
Repeatable: 3 times	☐	☐	☐
Content:			
The arithmetic of whole numbers and decimals	☐	☐	☐
The arithmetic of common fractions	☐	☐	☐
Ratios and proportions, percent, and scientific notation	☐	☐	☐
Calculator skills	☐	☐	☐
Perimeters, areas, and volumes of common geometric figures	☐	☐	☐
Powers and roots	☐	☐	☐
Arithmetic of signed numbers	☐	☐	☐
Solutions of simple linear equations and formulas	☐	☐	☐
Translation of word phrases to mathematical expressions	☐	☐	☐
Word problems and problem solving techniques	☐	☐	☐

Additional content items (Please list in the order of importance.):

1.

2.

3.

	NJ	A	D
Instructional formats available:			
5 hours lecture	☐	☐	☐
5 hours lecture/2 hours laboratory--In addition to the regular 5 hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	☐	☐	☐
5 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	☐	☐	☐

	NJ	A	D
5 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	☐	☐	☐

Please list, in order of importance, other desirable instructional formats that should be offered:

1.

2.

3.

3) Course:	☐	☐	☐

If you feel this course should not be offered, check D and skip to component 4.

Title: Arithmetic Fundamentals	☐	☐	☐
Units: 3	☐	☐	☐
Prerequisite: A non-negative body temperature	☐	☐	☐
Repeatable: 3 times	☐	☐	☐
Content:			
Counting, writing whole numbers in English, and expanded notation	☐	☐	☐
Arithmetic of whole numbers	☐	☐	☐
Arithmetic of common fractions	☐	☐	☐
Arithmetic of decimals	☐	☐	☐
Word problems, applications, and problem solving techniques	☐	☐	☐
Calculator skills	☐	☐	☐

Additional content items (Please list in the order of importance.):

1.

2.

3.

	NJ	A	D
Instructional formats available:			
3 hours lecture	☐	☐	☐
3 hours lecture/2 hours laboratory--In addition to the regular 3 hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	☐	☐	☐
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	☐	☐	☐
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	☐	☐	☐
Please list, in order of importance, other desirable instructional formats that should be offered:			
1.			
2.			
3.			
4. Course: If you feel this course should not be offered, check D and skip to component 5.	☐	☐	☐
Title: Mathematics Tutorial	☐	☐	☐
Units: 0.5	☐	☐	☐
Repeatable: 8 times	☐	☐	☐
Content: The student registers for a regular time to come to the math learning center to study and receive tutorial assistance.	☐	☐	☐
Instructional format: 2 hours tutoring per week.	☐	☐	☐

	NJ	A	D
5. Course: If you feel this course should not be offered, check D and skip to component 6.	☐	☐	☐
Title: Computer Laboratory	☐	☐	☐
Units: 0.5	☐	☐	☐
Repeatable: 8 times	☐	☐	☐
Content: The student registers for a regular time to come to the math learning center to study and do related computer aided tutorials, drill, and practice activities.	☐	☐	☐
Instructional format: 2 hours computer laboratory attendance per week.	☐	☐	☐

6. Please describe, in order of importance, other program components that should be included.

1.

2.

3.

APPENDIX G

FOURTH ROUND DELPHI COVER LETTER AND QUESTIONNAIRE

November 18, 1988

Dear ,

Please find attached the questionnaire for round four (the final round) of our Delphi exercise dealing with the basic mathematics program at Saddleback College. On this questionnaire are displayed the results from round three. Please reconsider your previous answers and respond to the items that have been added. These new items reflect comments that were made on the previous questionnaire.

I would also like to address a couple of points that should make interpretation of the results of round four more straight forward. Unless a course is specifically listed as repeatable, a student receiving a grade of C or higher may not repeat that class at Saddleback College. Of course, if a student does not received a grade of C or higher in a course, that student may always re-enroll in that same course. Currently no mathematics course is repeatable.

There were several comments on the round three questionnaire relative to the unit credit for the Basic Mathematics course. It was originally assigned more units than the Pre-Algebra course because it covered more material (in that the review of the arithmetic of whole numbers and decimals was not brief). It also was thought that some students might benefit from more contact each week with the instructor in a structured learning environment. If both courses are assigned the same number of units or contact hours (e.g. three), it is not clear why both should exist in the program. If you feel that both courses should have the same units, any comments you could make on your questionnaire in this area would be appreciated. They would help lead to an accurate interpretation of this response.

Please complete the round three questionnaire and return it by 3:00 p.m. Wednesday, November 30, 1988.

Sincerely,

Mathematics Department
Saddleback College
Basic Mathematics Program Study
Delphi Round Four: A Candidate Program

Please respond to the following questionnaire items by checking NJ if you have no judgment at this time, A if you agree, and D if you disagree. The number in each box corresponds to the number of responses from round three in that category. Your response from round three has been shaded red. If you wish to change your response from round three simply place a check in the box (write over the number you see there) corresponding to your desired response. If you do not wish to change your response from round three no action is necessary. Several additional items have been added to this questionnaire based on comments received on the round three questionnaire. These new items are marked with a * in the left margin. Please respond to these items as well as reconsidering your previous responses on the original items.

The basic mathematics program at Saddleback College should be composed of the following components:

	NJ	A	D
1) Course: If you feel this course should not be offered, check D and skip to component 2.	[0]	[13]	[0]
Title: Pre-Algebra Mathematics	[3]	[10]	[0]
*Title: Basic mathematics	[ ]	[ ]	[ ]
Units: 3	[4]	[9]	[0]
Prerequisite: Satisfactory score on the mathematics assessment examination	[4]	[9]	[0]
Repeatable: 0 times	[4]	[5]	[4]
*Repeatable: 1 time	[ ]	[ ]	[ ]
*Repeatable: 2 times	[ ]	[ ]	[ ]
Content:			
Brief review of the arithmetic of whole numbers and decimals	[0]	[13]	[0]
The arithmetic of common fractions	[0]	[13]	[0]

	NJ	A	D
Ratios and proportions, percent, and scientific notation	[0]	[13]	[0]
Calculator skills	[0]	[12]	[1]
Perimeters, areas, and volumes of common geometric figures	[1]	[12]	[0]
Powers and roots	[0]	[13]	[0]
Arithmetic of signed numbers	[0]	[13]	[0]
Solutions of simple linear equations and formulas	[0]	[13]	[0]
Translation of word phrases to mathematical expressions	[0]	[13]	[0]
Word problems and problem solving techniques	[0]	[13]	[0]
*Estimation/Approximation/Guessing at a result	[ ]	[ ]	[ ]
*Order of Operations	[ ]	[ ]	[ ]
*Mathematical visualization	[ ]	[ ]	[ ]
*Metric system	[ ]	[ ]	[ ]
*Measurement with stress on proper use of units	[ ]	[ ]	[ ]

Instructional formats available:

3 hours lecture	[0]	[8]	[5]
3 hours lecture/2 hours laboratory--In addition to the regular 3 hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	[1]	[10]	[2]
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	[5]	[6]	[2]

	NJ	A	D
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	[5]	[6]	[2]

2) Course: If you feel this course should not be offered, check D and skip to component 3.	[0]	[9]	[4]
Title: Basic Mathematics	[1]	[8]	[0]
Units: 5	[1]	[2]	[6]
*Units: 4	[ ]	[ ]	[ ]
*Units: 3	[ ]	[ ]	[ ]
Prerequisite: None	[1]	[7]	[1]
Repeatable: 3 times	[3]	[3]	[3]
*Repeatable: 2 times	[ ]	[ ]	[ ]
*Repeatable: 1 time	[ ]	[ ]	[ ]
*Repeatable: 0 times	[ ]	[ ]	[ ]
Content:			
The arithmetic of whole numbers and decimals	[0]	[9]	[0]
The arithmetic of common fractions	[0]	[9]	[0]
Ratios and proportions, percent, and scientific notation	[0]	[9]	[0]
Calculator skills	[0]	[9]	[0]
Perimeters, areas, and volumes of common geometric figures	[0]	[9]	[0]
Powers and roots	[1]	[7]	[1]
Arithmetic of signed numbers	[1]	[6]	[2]

	NJ	A	D
Solutions of simple linear equations and formulas	[1]	[6]	[2]
Translation of word phrases to mathematical expressions.	[0]	[7]	[2]
Word problems and problem solving techniques.	[0]	[9]	[0]
*Metric system	[ ]	[ ]	[ ]
*Emphasis on applications to everyday life	[ ]	[ ]	[ ]
*Order of operations	[ ]	[ ]	[ ]
*Rules of positive integer exponents	[ ]	[ ]	[ ]

Instructional formats available:

Let **X** *be the number of units you chose for this course above.*

X hours lecture	[0]	[2]	[7]
X hours lecture/2 hours laboratory--In addition to the regular **X** hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	[1]	[3]	[5]
X hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	[2]	[2]	[5]
X hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	[2]	[3]	[4]

---

3) Course: If you feel this course should not be offered, check D and skip to component 4.	[1]	[6]	[6]
Title: Arithmetic Fundamentals	[3]	[4]	[0]

	NJ	A	D
Units: 3	[3]	[3]	[1]
*Units: 0	[ ]	[ ]	[ ]
Prerequisite: None	[3]	[3]	[1]
Repeatable: 3 times	[3]	[2]	[2]
*Repeatable: 2 times	[ ]	[ ]	[ ]
*Repeatable: 1 time	[ ]	[ ]	[ ]
*Repeatable: 0 times	[ ]	[ ]	[ ]
Content:			
Counting, writing whole numbers in English, and expanded notation	[1]	[6]	[0]
Arithmetic of whole numbers	[1]	[6]	[0]
Arithmetic of common fractions	[1]	[6]	[0]
Arithmetic of decimals	[1]	[6]	[0]
Word problems, applications, and problem solving techniques	[1]	[6]	[0]
Calculator skills	[1]	[6]	[0]
*Some basic formula use	[ ]	[ ]	[ ]
*Estimating/Approximating	[ ]	[ ]	[ ]
Instructional formats available:			
3 hours lecture	[1]	[3]	[3]
3 hours lecture/2 hours laboratory--In addition to the regular 3 hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	[2]	[5]	[0]
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	[3]	[3]	[1]

	NJ	A	D
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	[2]	[4]	[1]
4. Course: If you feel this course should not be offered, check D and skip to component 5.	[0]	[12]	[1]
Title: Mathematics Tutorial	[2]	[10]	[0]
Units: 0.5	[2]	[9]	[1]
Repeatable: 8 times	[4]	[7]	[1]
Content: The student registers for a regular time to come to the math learning center to study and receive tutorial assistance.	[0]	[12]	[0]
Instructional format: 2 hours tutoring per week.	[2]	[10]	[0]
5. Course: If you feel this course should not be offered, check D and skip to component 6.	[1]	[10]	[2]
Title: Computer Laboratory	[5]	[5]	[1]
*Title: Mathematics Computer Assisted Instruction Laboratory	[ ]	[ ]	[ ]
Units: 0.5	[2]	[8]	[1]
Repeatable: 8 times	[4]	[6]	[1]
Content: The student registers for a regular time to come to the math learning center to study and do related computer aided tutorials, drill, and practice activities.	[1]	[10]	[0]

		NJ	A	D
	Instructional format: 2 hours computer laboratory attendance per week.	[2]	[9]	[0]
*6.	The mathematics tutorial course and the computer laboratory course should be merged into a single mathematics laboratory course.	[ ]	[ ]	[ ]
*7.	Students who sign-up for a mathematics course should be required to also sign-up for either the tutorial or computer lab.	[ ]	[ ]	[ ]

APPENDIX H

FOURTH ROUND DELPHI RESULTS

Mathematics Department
Saddleback College
Basic Mathematics Program Study
Delphi Round Four: A Candidate Program
Results

The basic mathematics program at Saddleback College should be composed of the following components:

	NJ	A	D
1) Course: If you feel this course should not be offered, check D and skip to component 2.	[0]	[13]	[0]
Title: Pre-Algebra Mathematics	[3]	[10]	[0]
*Title: Basic mathematics	[6]	[3]	[4]
Units: 3	[4]	[9]	[0]
Prerequisite: Satisfactory score on the mathematics assessment examination	[4]	[9]	[0]
Repeatable: 0 times	[2]	[6]	[5]
*Repeatable: 1 time	[2]	[7]	[4]
*Repeatable: 2 times	[2]	[0]	[11]

Looking at the three items immediately above as a group, it was found that four respondents supported repeatable one time,and three supported not repeatable.

Content:

	NJ	A	D
Brief review of the arithmetic of whole numbers and decimals	[0]	[13]	[0]
The arithmetic of common fractions	[0]	[13]	[0]
Ratios and proportions, percent, and scientific notation	[0]	[13]	[0]
Calculator skills	[0]	[13]	[0]
Perimeters, areas, and volumes of common geometric figures	[1]	[13]	[0]
Powers and roots	[0]	[13]	[0]
Arithmetic of signed numbers	[0]	[13]	[0]
Solutions of simple linear equations and formulas	[0]	[13]	[0]

	NJ	A	D
Translation of word phrases to mathematical expressions	[0]	[13]	[0]
Word problems and problem solving techniques	[0]	[13]	[0]
*Estimation/Approximation/Guessing at a result	[1]	[12]	[0]
*Order of Operations	[1]	[12]	[0]
*Mathematical visualization	[5]	[8]	[0]
*Metric system	[3]	[8]	[2]
*Measurement with stress on proper use of units	[2]	[11]	[0]
Instructional formats available:			
3 hours lecture	[0]	[9]	[4]
3 hours lecture/2 hours laboratory--In addition to the regular 3 hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	[1]	[11]	[1]
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	[4]	[8]	[1]
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	[4]	[8]	[1]

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2) Course: If you feel this course should not be offered, check D and skip to component 3.	[0]	[10]	[3]
Title: Basic Mathematics	[1]	[9]	[0]
Units: 5	[1]	[2]	[7]

	NJ	A	D
*Units: 4	[1]	[3]	[6]
*Units: 3	[2]	[5]	[3]

Looking at the three items immediately above it was found that four respondents supported three units, three supported four units, one supported five units, one supported either three or five units, and one had no judgment.

Prerequisite: None	[1]	[8]	[1]
Repeatable: 3 times	[1]	[3]	[6]
*Repeatable: 2 times	[1]	[3]	[6]
*Repeatable: 1 time	[1]	[2]	[7]
*Repeatable: 0.times	[1]	[3]	[6]

Looking at the three items immediately above it was found that five respondents supported course repeatability, four did not support repeatability, and one had no judgment. Among those supporting repeatability, two chose three times, two chose two times, and one chose one time.

Content:

The arithmetic of whole numbers and decimals	[0]	[10]	[0]
The arithmetic of common fractions	[0]	[10]	[0]
Ratios and proportions, percent, and scientific notation	[0]	[10]	[0]
Calculator skills	[0]	[10]	[0]
Perimeters, areas, and volumes of common geometric figures	[0]	[10]	[0]
Powers and roots	[1]	[8]	[1]
Arithmetic of signed numbers	[1]	[8]	[1]
Solutions of simple linear equations and formulas	[1]	[8]	[1]
Translation of word phrases to mathematical expressions.	[0]	[9]	[1]
Word problems and problem solving techniques.	[0]	[10]	[0]

	NJ	A	D
*Metric system	[2]	[7]	[1]
*Emphasis on applications to everyday life	[2]	[8]	[0]
*Order of operations	[2]	[8]	[0]
*Rules of positive integer exponents	[2]	[5]	[3]

Instructional formats available:

*Let **X** be the number of units you chose for this course above.*

	NJ	A	D
X hours lecture	[0]	[5]	[5]
X hours lecture/2 hours laboratory--In addition to the regular **X** hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	[1]	[6]	[3]
X hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	[2]	[5]	[3]
X hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	[2]	[6]	[2]

Looking at the four items immediately above it was found that two respondents liked none of these options. In addition to these faculty members, three did not like the lecture only option. Of these three one liked only the lec/lab combination, another liked only the self-paced lec/lab combination and the other had no judgment on the other alternatives. The remaining five respondents supported all four options.

	NJ	A	D
3) Course: If you feel this course should not be offered, check D and skip to component 4.	[1]	[6]	[6]
Title: Arithmetic Fundamentals	[3]	[4]	[0]

	NJ	A	D
Units: 3	[3]	[3]	[1]
*Units: 0	[2]	[2]	[3]
Prerequisite: None	[3]	[3]	[1]
Repeatable: 3 times	[2]	[2]	[3]
*Repeatable: 2 times	[2]	[1]	[4]
*Repeatable: 1 time	[2]	[0]	[5]
*Repeatable: 0 times	[2]	[2]	[3]
Content:			
Counting, writing whole numbers in English, and expanded notation	[1]	[6]	[0]
Arithmetic of whole numbers	[1]	[6]	[0]
Arithmetic of common fractions	[1]	[6]	[0]
Arithmetic of decimals	[1]	[6]	[0]
Word problems, applications, and problem solving techniques	[1]	[6]	[0]
Calculator skills	[1]	[6]	[0]
*Some basic formula use	[1]	[5]	[1]
*Estimating/Approximating	[1]	[6]	[0]
Instructional formats available:			
3 hours lecture	[1]	[4]	[2]
3 hours lecture/2 hours laboratory--In addition to the regular 3 hours lecture class, the student may sign up for a 2 hours per week math tutorial or CAI lab offered in the math learning center	[2]	[5]	[0]
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used	[3]	[4]	[0]

	NJ	A	D
3 hours self-paced (in a classroom setting, not independent study), open-entry/open-exit, mastery learning, mediated instruction used/2 hours laboratory--math tutorial or CAI lab	[2]	[5]	[0]
4. Course: If you feel this course should not be offered, check D and skip to component 5.	[0]	[12]	[1]
Title: Mathematics Tutorial	[2]	[10]	[0]
Units: 0.5	[2]	[10]	[0]
Repeatable: 8 times	[3]	[9]	[0]
Content: The student registers for a regular time to come to the math learning center to study and receive tutorial assistance.	[0]	[12]	[0]
Instructional format: 2 hours tutoring per week.	[2]	[10]	[0]
5. Course: If you feel this course should not be offered, check D and skip to component 6.	[1]	[10]	[2]
Title: Computer Laboratory	[4]	[4]	[3]
*Title: Mathematics Computer Assisted Instruction Laboratory	[3]	[8]	[0]
Units: 0.5	[2]	[9]	[0]
Repeatable: 8 times	[3]	[8]	[0]
Content: The student registers for a regular time to come to the math learning center to study and do related computer aided tutorials, drill, and practice activities.	[1]	[10]	[0]

	NJ	A	D
Instructional format: 2 hours computer laboratory attendance per week.	[2]	[9]	[0]
*6. The mathematics tutorial course and the computer laboratory course should be merged into a single mathematics laboratory course.	[4]	[6]	[3]
*7. Students who sign-up for a mathematics course should be required to also sign-up for either the tutorial or computer lab.	[2]	[9]	[2]

APPENDIX I

PROGRAM COST ANALYSIS

PROGRAM COST ANALYSIS

For the 1988 spring term 424 students enrolled in Basic Mathematics at Saddleback College. These students were enrolled in eight different class sections and three of these were given in a large lecture mode. The enrollment ceiling in these three sections was set at ninety students. Basic Mathematics became a developmental course in the 1988 fall term. Consequently, large lecture sections were no longer permissible under college instructional policy. For the purposes of comparison between the recommended and existing program it was necessary to remove the large lecture section capability from the 1988 spring term data. Thus it was assumed that twelve sections that averaged thirty-five students each were used to serve the 424 students enrolled in the 1988 spring term. From the instructor grade sheets for these students, it was found that 320 students received a final letter grade (A, B, C, D, or F) in this course. The amount of state support (three thousand dollars per ADA) generated by these students was calculated using expression 1 and found to be approximately $96,000.

(1) $\$3000 * (0.5 * (C1+C2) * H * 16.6 * 0.911) \div 525$

where: C1 was the number of students enrolled at the first census,

C2 was the number of students enrolled at the second census,

H was the number of hours the class met each week,

16.6 was the number of weeks in a semester, 0.911 was the state mandated attendance factor,

525 was the hours necessary for each ADA.

The expenditure required to offer these sections was measured in terms of the number of full-time equivalent instructors needed. Expression 2 was used for this purpose.

$$S * H \div 30 \qquad (2)$$

where: S was the number of course sections,

H was the number of hours the class met each week,

30 was the number of lecture hours taught by a full-time equivalent faculty member each academic year.

The number of full-time equivalent instructors was found to be 1.2. Using the current expenditure level of fifty-thousand dollars for each full-time equivalent instructor (Carroll, 1988:6), the cost of the basic mathematics program was approximately sixty thousand dollars. Consequently the income to the college for the basic mathematics program was $36,000. These monies were used to cover administrative services, physical plant maintenance, and other support services required for college operation.

The derivation of a set of comparable figures for the recommended basic mathematics program required the establishment of several assumptions. These assumptions were as follows. Again, a base of 424 students in twelve sections was assumed. It was further assumed that sixty percent of these students would enroll in the pre-algebra course and the remainder in the basic mathematics course. In each case one section would be individualized and the remainder would have a lecture format. The number of students who would choose to enroll in the optional tutorial laboratory was assumed to be forty percent of the total. As a consequence, 170 students would enroll in the tutorial sections. There would be five laboratory sections and each would be staffed by an instructor and two peer tutors. The peer tutors would be paid the minimum wage of $4.25 per hour. Students enrolled in laboratories generated ADA at the same rate as those enrolled in lecture classes. The instructor of laboratory classes was given only one hour credit toward the full-time equivalent instructor load of thirty hours for two hours of laboratory duty. It was assumed that the proposed program would better meet the needs of students than the existent program. A reduced withdrawal rate between first and second census of fifteen percent rather than the current twenty-five percent would therefore be observed. It was also anticipated that a higher ratio of those completing the course would achieve grades of A, B, or C but this program improvement had no impact on the program cost. Both of these assumptions were consistent with the research findings cited by Boylan (1983:33).

Expenditure and revenue calculations using expressions (1) and (2) were applied to a model based on the assumptions noted above. It was found that the program generated approximately $139,000 with an expenditure for salaries and benefits of approximately $78,000.

Consequently, the income to the college was approximately $61,000. This income represented an increase of nearly seventy percent over that provided by the existent program.

Income projections may prove optimistic. However, it was clear that the potential existed for an improvement in the educational practice at the college with a smaller expenditure of limited college funds than required for the current program.

BIOGRAPHICAL SKETCH OF PARTICIPANT

BIOGRAPHICAL SKETCH

Steven Sworder is an instructor of mathematics at Saddleback College, Mission Viejo, California. He teaches courses from all phases of the mathematics curriculum, but maintains a particular interest in the developmental mathematics and engineering mathematics programs. He served as the chairperson for mathematics department for three years at Saddleback College and for one year at Sierra College, Rocklin, California. He was employed as a systems engineer for a total of eleven years with several aerospace firms based in the greater Los Angeles, California area.

Mr. Sworder received the Doctor of Philosophy Degree in engineering, the Master of Science Degree in engineering, and the Master of Arts in Teaching Degree in mathematics from the University of California, Los Angeles. He received the Bachelor of Science Degree in electrical engineering from the University of California, Berkeley and the Associate of Arts Degree in engineering from Fullerton Junior College, California. He is a member of several honor societies including: Phi Beta Kappa, Tau Beta Pi, and Alpha Gamma Sigma.